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ABSTRACT

A study was conducted to assess trends in the supply and demand for environmental hazardous materials (EHM) technical and related workers and to identify the skills and knowledge required of personnel in these positions. Information for the study was gathered through interviews, focus groups, and data from a mailed survey of employers of EHM personnel in private industry and Department of Energy facilities (n=128) and educators in community colleges (n=94). Some of the findings were the following: (1) an adequate supply of trained technician-level personnel in the environmental management industry is not readily available, and demand for such technicians will increase moderately to substantially in the near future; (2) employers prefer EHM personnel with community college training, although they are frequently unable to find sufficient numbers of applicants with this background; (3) many industry representatives promote expanding vocational programs at community colleges to provide more trained technician-level personnel; (4) employers want technicians to be well trained in verbal and written communication, problem solving, comprehension of technical material, and teamwork; (5) technicians are also expected to have a core set of academic competencies such as high school and college science and mathematics and to have knowledge of specific industry-related tasks and responsibilities; (6) implications for education include the need for new program development and increased enrollment capacity in EHM technician programs; and (7) training needs include short courses for current employees and a comprehensive and integrated vocational and academic program leading to a certificate or associate degree. (The report includes a list of 86 references, a bibliography containing 106 citations, and 7 appendixes containing project surveys, interview findings, EHM skills questionnaires, employer rankings of skills and knowledge areas, and an assessment of the labor market and educational needs for hazardous materials technicians and related workers.) (KC)

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National Center for Research in Vocational Education

University of California, Berkeley

# EDUCATIONAL NEEDS AND EMPLOYMENT TRENDS OF ENVIRONMENTAL HAZARDOUS MATERIALS TECHNICIANS AND RELATED WORKERS

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# EDUCATIONAL NEEDS AND EMPLOYMENT TRENDS OF ENVIRONMENTAL HAZARDOUS MATERIALS TECHNICIANS AND RELATED WORKERS

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# FOREWORD

This project has benefited from the generous support of two Federal agencies: the U.S. Department of Education through the National Center for Research in Vocational Education, University of California at Berkeley (NCRVE) and the U.S. Department of Energy (DOE) through its Office of Contractor Human Resource Management. NCRVE conducts applied research and development in vocational education under authorization of the Carl D. Perkins Vocational Education Act. It also supports research and publishes papers on issues related to vocational education in the United States. Among its several missions, NCRVE seeks to use the results of this research to shape debates over the role of education. Pursuant to that objective, NCRVE supports research on a wide variety of topics, including studies of changing employment requirements in various occupations and industries and the role that education can play in meeting changing employer needs. This study was conducted to support that objective.

The DOE has embarked on an ambitious program to identify and cleanup hazardous waste sites at its facilities throughout the nation. To achieve that goal, the DOE actively participates in a variety of efforts that assist postsecondary educational institutions in educating and training environmental personnel. The DOE's Office of Industrial Relations supported this project as a source of information that will benefit decision making about involvement in these educational programs.

This report presents the results of a two-year study of technician-level environmental personnel. The study's major goal was to assess current and projected needs for these environmental technicians and the extent to which existing educational programs are meeting these needs. To achieve this goal, the research examined the skills that employers require of environmental technicians and the adequacy of the current labor supply, assessed the fit between employer needs and environmental curricula at two-year postsecondary institutions, identified the implications of these findings for vocational education in the environmental field, and identified the role of partnerships between industry and education in meeting the training and retraining needs of the environmental industry.

Readers interested in obtaining additional results from the surveys described in this report may contact the authors at MPR Associates in Berkeley, California.

# ACKNOWLEDGMENTS

We wish to thank the many managers, supervisors, and technicians at DOE facilities and private environmental firms and the large number of environmental educators whom we interviewed and who responded to our surveys or participated in our focus groups. They were extremely generous with their time and thoughtful comments about critical environmental issues, especially labor force and educational needs.

We would also like to thank the industry representatives, educators, and government personnel who are members of the Partnership for Environmental Technology Education and commented on the research at critical junctures. While they do not bear responsibility for the conclusions drawn in this report, they played a key role in the development and success of the project. Special thanks go to Paul Dickinson from the Lawrence Livermore National Laboratory, who helped us identify participants for the private industry interviews and surveys, and Armin Behr, who arranged for our visits to DOE facilities and provided major financial support from DOE for the project.

This report was prepared under a grant from the National Center for Research in Vocational Education (NCRVE), University of California at Berkeley. We gratefully acknowledge the encouragement and support of Charles S. Benson, Director, and Gerald Hayward, Deputy Director, of NCRVE. The report was edited by Andrea Livingston and Brett Threlkeld, graphics were developed by Leslie Retallick, and secretarial support was provided by Melinda Hobbs—all of MPR Associates, Inc. Their efforts and contributions are greatly appreciated.

# EXECUTIVE SUMMARY

## Study Sponsorship and Goals

This report presents results from a study of environmental hazardous materials (EHM) technicians and related personnel employed by the U.S. Department of Energy (DOE) and in private industry. With funding from the U.S. Department of Education through the National Center for Research in Vocational Education (NCRVE) and the DOE, this research provides an assessment of trends in the supply and demand for EHM technicians and related workers, identifies the skills and knowledge required of personnel in these positions, includes an overview of different types of programs that exist to educate and train these technicians, and offers recommendations to individuals in industry and education who are responsible for planning and developing technician-level training and education programs.

## Research Methodology

This study examines labor market trends, educational needs, and skill requirements related to training and employment of EHM personnel based on interviews, focus groups, and survey data. Our experience with similar studies of other technical occupational fields has demonstrated that the expert opinions of managers and supervisors of personnel gathered through these methods provide current and accurate information about the competency requirements for such personnel. Together with employment projections and industry trends, this data can be used to evaluate and implement educational programs for training personnel in a specific industry.

The results of this study are based upon data gathered in two stages. First, the researchers met with experts in the environmental management field, including employers and educators of EHM personnel, to create a foundation of hypotheses about trends in the environmental industry and a preliminary list of skills required by employers of EHM technicians. From the results of these interviews, we created a mail survey that was distributed to a much larger sample of employers and educators of EHM technicians. The sample populations for both the interviews and the survey mailing included employers of EHM personnel from private industry and DOE facilities and educators primarily representing community colleges.

## Summary of Findings

The findings from this study can be grouped into three broad categories: trends in employment needs for EHM technicians and related workers, educational implications resulting from these expected trends in employment, and issues related to program planning for EHM technician education and training. These issues are summarized below.

### Industry Trends and Needs

American educators are responsible for adequately preparing and training our nation's work force. Also, as our economy and industries continue to experience rapid change as a result of internal and external forces, educators must implement parallel adjustments in programs and curricula to address new levels of demand for personnel and new skill requirements. Educators must continually conduct research into industries' employment needs and analyze the job market to predict fluctuations in levels of hiring. This study discusses the relevant educational issues related to employment trends in the environmental management industry.

The majority of experts surveyed and interviewed during this study concluded that an adequate supply of trained technician-level personnel in the environmental management industry is not readily available. These same individuals expect that demand for such personnel will increase moderately to substantially in the near future. In order to overcome this shortfall, some managers have been forced to hire overqualified applicants or spend considerable amounts of money and time training underqualified individuals to perform required tasks. With the costs of environmental cleanup and management rising to ever higher levels—coupled with the federal, state, and local mandates that require industry to meet certain environmental standards—it is crucial that industry find more cost-effective alternatives for recruiting appropriately trained environmental personnel.

The majority of industry representatives who anticipated recruiting additional EHM personnel indicated that the most desirable education for technicians is some type of community college-level preparation. Unfortunately, these same representatives were frequently unable to find sufficient numbers of applicants with this background. As a result, many industry representatives interviewed for this study promote expanding vocational programs at community colleges, either degree or nondegree, to provide a more adequate pool of trained technician-level personnel.

This study demonstrated that the skills required of technician-level environmental personnel are remarkably consistent across a broad range of specific occupations in both private-sector and DOE employment. With regard to educational competencies, we identified three general skill areas that employers require of their entry-level technicians. Most importantly, employers acknowledged a need for applicants to be well trained in fundamental nontechnical skills that can be applied to many employment activities. These include verbal and written communication, problem solving, comprehension of technical material, teamwork, and time management.

Employers also acknowledged a core set of academic competencies that technicians must master. These academic competencies include relatively basic levels of high school and college science and mathematics, including algebra and trigonometry. Courses in these areas provide technicians with the technical background for understanding the dynamics of the hazardous materials with which they work. To a somewhat lesser extent, employers desire that their technicians have knowledge of specific industry-related tasks and responsibilities. Most important among these are record keeping; maintaining personal and area protection; knowledge of Occupational Safety and Health Administration (OSHA), Comprehensive Environmental Response, Compensation, and Recovery Act of 1980 (CERCLA), and Resource Conservation and Recovery Act of 1976 (RCRA) regulations; and hazardous materials and waste handling.

In general, educational administrators and instructors that were surveyed confirmed the conclusions about necessary skills and desired educational programs for technicians that resulted from our survey of employers. Many educational institutions have assessed the local demand for EHM personnel and have responded by implementing new or expanded vocational training programs. Educators who have developed EHM programs at their schools have placed a very strong emphasis on virtually all the skills and knowledge that were recognized as important by employers of technician-level personnel. Consequently, where programs exist, there is a very good fit between the types of education received by environmental personnel and the skill requirements of industry.

### Educational Implications

New program development and increased enrollment capacity would help bridge the gap between industry demand and educational supply for EHM technicians. The results of our research suggest that the most desirable level of educational attainment needed to convey the necessary knowledge and competencies for EHM technicians is offered at the community college level, whether through a formal degree program or individual short courses. We strongly recommend that community colleges throughout the nation assess the demand for environmental personnel in their region or community. Based upon these assessments, we suggest that two-year institutions develop programs to meet these needs.

In addition to new program implementation and enrollment capacity increases at postsecondary institutions, we suggest that community colleges establish links with secondary-level vocational education programs to increase the number of high school students that successfully pursue postsecondary environmental programs. Because of the need for a more technically trained applicant pool across all industries, articulation programs between secondary schools and postsecondary vocational programs have moved to the forefront of the national educational agenda. Applied academic programs at the secondary level can increase students' abilities to transfer their knowledge to a clear vocational goal after graduation. A solid foundation of math, science, and communications courses at the secondary level will prepare students for a variety of technical vocational programs at the postsecondary level, including environmental hazardous material management. Adequate preparation at the secondary level will reduce the primary obstacle that currently prevents students from completing environmental programs—a lack of fundamental math and science skills necessary to pursue the technical issues related to the industry. The integration of secondary-level training with two-year postsecondary education is an excellent strategy for preparing a qualified cadre of personnel to meet the current and expected employment needs of the EHM industry.

### Program Planning

Our findings clearly indicate that no single training program will be suitable to all employers of EHM personnel. In some instances, employers already have a relatively sophisticated and educated pool of employees who need only limited retraining to perform in environmental management jobs. In these cases, short courses that focus on laws regulating hazardous materials used on the job and other specific technical areas are probably most appropriate. In other cases, employers are looking to the outside labor market as a source of individuals to perform more general support functions related to the management of hazardous materials. The most desirable type of educational attainment for these employees is achieved through a comprehensive and integrated vocational and academic program such as a certificate or associate degree.

In order to determine what programs or courses are most suitable for each community college, it is crucial that industry and education partnerships are established to communicate the needs of both entities. Through these relationships, educational administrators may target the needs of employers; industry officials can help establish competencies and curricula; cooperative use of facilities and equipment can be arranged; and cost-effective education and employment programs can be developed.

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# INTRODUCTION

## Statement of the Problem

For nearly fifty years, the nation's defense industry and the domestic nuclear power industry have been creating nuclear and other hazardous waste as by-products of their ongoing operations. Over a much longer period—in fact, since before the industrial revolution—industries as diverse as agriculture, chemical processing, mining, and textile manufacturing have also produced hazardous waste as a result of their normal business activities. Until the past two decades, the environmental and health consequences of hazardous waste production received only limited attention from the public or from government regulators. Now, however, industry, federal agencies, and the public are focusing on the need to identify safer methods of handling environmentally hazardous materials and on the safe and permanent disposal of nuclear and other hazardous waste.

As a result of rapidly expanding legislation and regulation at the local, state, and federal levels, these environmental management activities have become a national priority requiring immediate action. These activities have also spawned a new, expanding sector of the work force that includes a wide array of environmental positions, ranging from the highest level scientific and environmental engineering functions to many manual labor jobs that require both physical strength and knowledge about the safe handling of hazardous materials. Given the magnitude of the hazardous waste problem and the continuing high level of public support for cleanup efforts, environmental management will continue to be of paramount concern well into the next century. Of equal importance will be the need for individuals who are trained to perform the diversity of environmental jobs and who are educated to understand and use the complex and evolving technologies of this industry.

### Strategic Planning for Environmental Personnel

Appropriate work-force development strategies for handling environmental hazardous materials, minimizing waste production, and disposing of hazardous waste must be developed if the United States is to meet the challenge of cleaning up the environment. To implement these strategies, it will first be necessary to identify national requirements for technically trained environmental personnel, to establish the types of skills and knowledge needed by these workers, and to develop education and training programs that will successfully fulfill these human resource needs. Strategic human resource planning for an environmental work force will require

- a clear understanding of the demand for environmental personnel, including human resource needs at various occupational levels;
- a detailed mapping of the skills and knowledge that the environmental work force must possess at each occupational level;
- an appreciation of the contributions that public education, private training programs, and on-the-job training can make to developing the skills of environmental workers and an integrated plan for using all of these programs; and
- a commitment of necessary technical and financial resources to develop and maintain education and training programs for environmental employees at all levels, and to support the continuing education of environmental personnel who are constantly facing the demands of newer, more complex technologies.

### *Quantitative Supply/Demand Estimates Are Lacking*

How many employees will be needed to accomplish the nation's environmental agenda? Definitive answers to this question are lacking because at the national level, the demand for environmentally trained personnel and the current supply of these individuals are not well documented. However, more limited studies have addressed these issues and suggest that future work-force needs currently are substantial and are likely to grow in the future.

For example, studies focusing on local labor markets have produced some employment estimates for specific regions such as eastern Washington State and the San Francisco Bay Area (Bay Area Council and Bay Area Bioscience Center, 1991; Liddell & Cochran, 1990); for broad industry sectors, without regard to specific occupational levels (Ferrier, 1992; Milnes, 1991); for professional-level environmental workers (U.S. Department of Health and Human Services, 1990); or for single large employers such as the U.S. Department of Energy (Holmes & Lewis, 1991; Oak Ridge Associated Universities, 1990). In addition, since 1989, California Community Colleges have analyzed nearly eighteen-hundred employer surveys assessing employment demand in the environmental field. Nearly all these studies suggest that there will be growing demand for environmental workers. However, there are no reliable estimates for the entire nation on the numbers of individuals who make up the current work force or on how many employees will be needed in the future at specific occupational levels across all employment sectors.

Several factors have contributed to our lack of data and knowledge about these work-force issues. Because many environmental occupations are still in their infancy, numbers of formally trained personnel tend to be small and numbers of formal education programs are even smaller. As a result, many individuals performing jobs related to hazardous materials and waste have developed their job-based knowledge and skills solely through on-the-job training. Consequently, existing data on graduates from postsecondary environmental programs—frequently a good source of data on new work-force entrants in specific fields—tells us little about the growth of the "hazmat" work force.

In addition, U.S. Department of Labor and state-level employment statistics have not yet been collected for most detailed environmental occupations. For example, in 1992, California's Employment Development Department's Labor Market Information Division initiated its first data collection effort for hazardous waste and related technician occupations, which was limited to only a small sample of labor markets. Further, even if these statistics had been collected using traditional job titles and descriptions, many individuals working in environmental jobs would have been overlooked because they are classified into administrative, engineering, or facilities management functions where their job titles do not reflect their environmental responsibilities.

For example, in today's work force, employees holding such job titles as Safety Manager or Facilities Manager often have major responsibility for monitoring and disposing of their companies' hazardous wastes. This situation exists particularly in smaller companies where employees routinely perform several job functions, none of which adequately entails the full scope of their responsibilities. As a result of these employment patterns and current data gathering practices, estimates of supply and demand at the national level are lacking, they cannot be extracted from published data sources, and they are even difficult to construct from existing corporate survey data.

### *Skill Requirements Are Not Well Understood*

There is a similar scarcity of information based on large, national samples of employees about the specific skills required in many jobs that deal with the environmental impact of hazardous materials and waste. While some educational programs have conducted assessments of the environmental competencies employers require in order to develop their own curricula, these evaluations are generally based on limited local samples of employers and have very low response rates. In addition, the results of these efforts are generally not made available to individuals outside of the educational institutions that conduct the studies.

Nevertheless, it is clear from even a cursory examination of many environmental jobs that generally the skills required of environmental workers are highly technical and their complexity will almost certainly increase in the future as a result of new technological innovations and increasing government regulations. Many employers have recognized that these workers require specialized and technical postsecondary-level education, especially as government certification requirements have been increased for specific fields such as asbestos management and even for routine handling of hazardous waste. The recent proliferation of environmental education programs and vendor-sponsored training institutes affirms that there is a substantial and growing market for these specialized environmental training programs and also reflects the entrepreneurial nature of the training industry in the United States.

However, in order to meet the future demand for employees as environmental jobs proliferate, there must be a clear definition of what is necessary in terms of levels and types of environmental education. Specifically, education policymakers must focus on identifying the right combination of educational programs that will meet diverse national needs for training and educating environmental workers. In so doing, they must address questions such as the following:

- To what extent should environmental industries rely on baccalaureate-level engineers and science graduates for waste management and environmental remediation work?

- What is the need for individuals who have completed certificates or associate degrees, rather than baccalaureate degrees; and could employing these individuals enhance industry productivity?

- What will be the future demand for environmental "short courses" that deliver specialized technical knowledge in short, intensive doses; and should these courses be tied to broader environmental education curricula?

- Can these short courses and/or associate degree programs be used to retrain workers whose jobs are being eliminated due to technological change or shifts in America's industrial infrastructure?

### *Matching Education to Employment Needs*

Understanding the role of technician-level employees in the larger environmental work force is critical to addressing these questions. Toward this end, MPR Associates' research staff embarked on this study to identify the need for *technician-level* personnel and to determine whether demand for these employees would grow in the future. Although study staff posited that environmental hazardous materials (EHM) technicians generally do not need baccalaureate degrees, they do need specialized technical and basic education that will lead to either certification in the environmental field or an associate degree. This study was designed to determine whether this hypothesis is accurate and whether certificate and associate degree programs are preparing technicians to meet industry needs.

Questions about the role of hazardous materials technicians are important ones, especially because work-force productivity depends on the availability of appropriately educated individuals to perform environmental jobs. Yet these technician-level personnel have received the least attention in previous research of any segment of the environmental work force. Indeed, they are the segment about which we know the least, for which we may have the greatest long-term need, and for whom we have the fewest educational programs. As a result, in order to accomplish our national environmental agenda, we must obtain answers to a variety of labor market and skill questions about environmental technicians, their role in the nation's environmental effort, and their educational requirements.

## Origins of This Study and Funding Sources

Because of the importance of these human resource and educational issues, the National Center for Research in Vocational Education (NCRVE), University of California at Berkeley, provided initial funding for this two-year study of national needs for EHM technicians. Among its several missions, NCRVE supports research on a wide variety of topics, including studies of changing employment requirements in various occupations and industries and the role that education can play in meeting changing employer needs. This study received NCRVE support pursuant to that objective.

In addition to assistance from NCRVE, this study has benefited from the generous technical and financial support of the Office of Industrial Relations of the U.S. Department of Energy (DOE) through the Partnership for Environmental Technology Education (PETE). The mission of PETE is to implement a partnership among community colleges, federal agencies such as DOE and the U.S. Environmental Protection Agency (EPA), and private industry to increase the availability and enhance the training of professional and technician-level environmental personnel.

## Goals and Objectives of the Research

### *Overall Project Goals and Objectives*

The goals of this study are to provide an assessment of the demand for EHM technicians and related workers, to identify the skills and knowledge required of personnel in these positions, and to communicate this information to individuals in industry and education who are responsible for planning and developing technician-level training and education programs. The focus of this study is on the supply, demand, and educational requirements of individuals who collect, transport, handle, store, and dispose of toxic wastes and who require postsecondary-level technical training or education.

To achieve these goals, the study identified seven objectives:

1. To identify trends in labor market demand for EHM technicians in the public and private sectors, including both personnel and skill requirements.

2. To estimate the adequacy of the current supply of EHM technicians, including differences across employment sectors and industries.

3. To assess the gap between available personnel and national needs.

4. To evaluate the fit between skills required by employers and skills currently being developed in environmental education programs.

5. To identify major sources of education and training for EHM technicians, trends in enrollment in and graduation from these programs, and types of curricula currently being offered.

6. To provide recommendations concerning the development of new or expanded education and training programs and possible modifications of existing curricula.

7. To communicate this information to the vocational education and environmental employment communities.

***Research Questions***

In this report, MPR researchers will meet these objectives by presenting the study's findings on a number of questions, including the following:

*Objective 1*: *To identify trends in labor market demand for EHM technicians in the public and private sectors, including both personnel and skill requirements.*

- What are the major regulatory, legal, technological, social, and economic factors that are driving current demand for EHM technicians and workers; and how are they likely to affect future demand?

- What is the current demand for EHM technicians in public- and private-sector employment? How will future demand for these technical specialists be affected by Department of Defense (DoD), DOE, and EPA spending levels and by legislated regulatory requirements?

- What are the various jobs of employees whose work involves major responsibility for handling environmental hazardous materials and waste? Where are they employed in the public and private sectors and across various industries? What are their duties and responsibilities?

- What are the job knowledge and specific work skill requirements for EHM technicians in public- and private-sector employment? How do these knowledge and skill requirements differ in the two sectors?

*Objective 2*: *To estimate the adequacy of the current supply of EHM technicians, including differences across employment sectors and industries.*

- What is the assessment of public- and private-sector managers concerning the adequacy of the current supply of EHM technicians? How difficult has it been for managers to hire qualified individuals to fill open positions?

*Objective 3*: *To assess the gap between available personnel and current needs.*

- Does the supply of trained EHM technicians appear to meet existing public- and private-sector needs? Will this supply meet future needs at various potential demand levels?

*Objective 4*: *To evaluate the fit between skills required by employers and skills currently being developed in environmental education programs.*

- Are the curricular content of existing programs and skills of graduates meeting public- and private-sector industry requirements?
- What modifications to current public programs could enable them to respond more effectively to current and projected public-sector and industry needs? What kinds of new programs may be necessary?

*Objective 5*: *To identify major sources of education and training for EHM technicians, trends in enrollment and graduation from these programs, and types of curricula currently being offered.*

- What are the current institutional sources of personnel trained to handle environmental hazardous materials?
- What are the trends in numbers of programs offering education for EHM technicians, and what are the trends in enrollments and graduation? To

what extent are entry-level EHM technicians receiving training at various types of educational institutions, and how frequently are technicians trained on the job?

- What material is taught and what skills are developed in current EHM technician education and training programs, and what are the curricula in these programs?
- Is there a common core of skills and knowledge that crosses various EHM technician jobs, and if so, can a single curriculum deliver the appropriate educational material to students preparing for a variety of technician-level jobs?

## Research Methodology

### Evaluation of Supply and Demand

Statistical labor market supply and demand estimates for individual occupations require accurate labor market data for all employment sectors in which that occupation is found. In the case of EHM technicians that list would include all public-sector employers such as the DoD, DOE, EPA and local, state, and federal governments as well as all private companies that produce and handle their own hazardous waste or perform hazardous waste services for other companies. As already indicated, this data has not yet been published for EHM technicians and related workers because existing national and state employment surveys generally do not include most environmental technician job titles and many environmental workers hold unrelated job titles. Furthermore, the task of generating this information from a population survey designed especially for this study would be extremely expensive, an undertaking far beyond the scope of this project.

Nevertheless, this study was predicated on the view that useful assessments of labor market supply and demand can be created from a much more limited sampling combined with the analysis of qualitative data. More specifically, our experience with similar studies of advanced manufacturing, computer-aided design/drafting, and allied health occupations (Hudis, 1990; Hudis, 1991; Hudis et al., 1992) has demonstrated that the expert opinions and experience of employers and educators can provide reliable data about employment conditions.

Consequently, in this study, research staff generated information about trends in labor market supply and demand from the informed responses of managers and supervisors who employ EHM technicians and from educators and program administrators who are responsible for community college-level environmental programs. Specifically, the results presented in this report are based on in-depth interviews—almost always conducted in person but occasionally by telephone—and mail surveys containing a variety of questions related to the supply/demand equation. These interview and questionnaire items include queries about managers' experiences related to recruitment difficulties, employee turnover, use of professional engineers or scientists to fill technician-level jobs, and educators' experiences with placing new graduates.

## Job Analysis and the Study of Occupational Skill Requirements

### *Rationale for Using Job Analysis Methods*

Our goals in this study are (1) to identify the skills that employers require EHM technicians to possess and (2) to assess supply and demand trends for these workers. To meet the first goal, MPR researchers used traditional job analysis survey methods to collect and analyze data on the knowledge and skill requirements of EHM technicians and related workers. Broadly defined, *job analysis* is a process by which jobs are disaggregated into their component parts, usually known as tasks, by using a systematic procedure for data collection, analysis, and synthesis (Bemis, Belenky, & Soder, 1983; McCormick, 1976). These methods can be used to generate data on the relative importance of each task to overall job performance and on the skills and knowledge required to perform each task. Job analysis techniques were chosen for our data collection for several reasons:

- Job skill elements gathered from job analyses can be used to identify the specific competencies that educators require for competency-based curriculum development. Therefore, detailed occupational skill information obtained from this study will be useful to educators and trainers who are developing curricula for EHM technicians and related training programs.

- Job analysis data provides the specificity about occupational skills that is necessary for meaningful comparisons across occupations. These comparisons are central to our objective of identifying skills that are common to most EHM-related positions.

- Job analysis methods are widely employed in industry to develop job descriptions that are used for hiring technically skilled and other employees. Consequently, using this method will enable us to supplement our own data on job skill requirements with information contained in current job descriptions.

### *The Task-Inventory Job Analysis Method*

Although they share many similarities, there are several job analysis approaches. Based on our previous work using these techniques to study occupational skill requirements (Hudis, 1990; Hudis, 1991; Hudis et al., 1992), MPR staff chose a type of task-inventory job analysis approach for this study (Bemis et al., 1983). Standard task-inventory job analysis involves a three-step data collection process:

1. The first step is to generate a list of job tasks. This information is gathered during *inventory construction interviews,* which are in-depth, face-to-face meetings between the researcher and the job incumbents. In these interviews, respondents provide detailed information about the specific tasks they perform in their jobs and the skills, knowledge, and abilities that are necessary to perform these tasks. The researcher does not present respondents with a preexisting task list during the interview; instead, respondents produce their own list, thereby reducing the impact of the analyst's biases on the data.

2. The second data collection step involves creating task statements that describe job-related behaviors. These statements are compilations of the tasks that were elicited from the interviews. Taken together, all task statements about a particular job constitute a *task inventory* that can later be used to identify task dimensions such as the frequency of task performance, the importance of the task to the total job, the length of training time required to master a particular task, and whether the task is best learned in school or on the job. The complete task inventory is then converted into a questionnaire, and rating scales are assigned to each item to measure frequency, importance, training time, and other task dimensions.

3. As a final step, the researchers administer and evaluate responses to task inventory questionnaires and determine the relevant skills, knowledge, and abilities required for each task and for each job.

## Intensive Interviews Conducted for This Study

To develop the task inventories for EHM technicians—and to begin collecting information on employers' estimates of supply and demand patterns—three members of MPR's staff, the project director and two project analysts, conducted 144 face-to-face interviews at eleven DOE facilities and ten private companies. All of these interviews were conducted with individuals who are highly knowledgeable about environmental hazardous materials, hazardous waste operations, and the job responsibilities of EHM technicians and related workers. These interviews generally lasted about one hour.

Because of difficulties associated with identifying the population of employers who use EHM technicians, MPR research staff did not attempt to draw a probability sample for these interviews or for the employer survey that followed. Instead, we relied on a "snowball" sampling technique that helped us identify various types of private-sector environmental employers and knowledgeable supervisors and managers in these companies and at DOE facilities. Specifically, we worked with contact personnel identified by the DOE's Office of Industrial Relations and with members of the Partnership for Environmental Technology Education (PETE)[1] to select managers who were knowledgeable about a broad spectrum of work settings in which EHM technicians and related workers are employed.

Once these individuals were identified, the researchers contacted potential respondents by mail and then by telephone to set up interviews at the respondents' convenience. Cooperation from all organizations initially contacted was excellent, and only two private companies declined to have their managers or employees interviewed. Once on site, the researchers conducted two types of interviews. First, they interviewed management personnel with general responsibility for environmental safety, site restoration, and/or hazardous waste management functions or with responsibility for developing EHM training programs. These interviews with management provided information on the organizational locations in which EHM technician and related jobs are performed, the current education and training backgrounds of EHM technicians, and the skills that are most needed.

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[1] PETE is a consortium of government agencies, private employers, and community colleges in five western states that is dedicated to improving the public education of the environmental work force. The group is funded by the U.S. Department of Energy and the U.S. Environmental Protection Agency.

Second, the researchers interviewed experts who were directly involved with handling radioactive and/or other hazardous waste. Many of these experts were EHM technicians or were employed in related job categories. Others were first-line supervisors or foremen who were directly responsible for overseeing the work of the technicians. In many instances the supervisors had previously been incumbents of the technician-level jobs. When developing the interview sample, it was explicitly indicated that we wanted to interview individuals with at least two to three years of experience in their environment-related jobs. As a result, the individuals in our sample had a very high level of detailed and current knowledge about the skills required in these environmental jobs.

The researchers used standard interview protocols for interviews with managers, supervisors, and technicians at all sites but also allowed time for respondents to raise important issues that might have been missed in developing the protocol. These three protocols were similar, although the managers were the only respondents who were asked questions directly related to recruitment and employee turnover. Respondents at all DOE facilities and every company visited were very cooperative in providing access to their personnel and facilities. We believe that their responses to interview questions were candid and comprehensive. From detailed notes taken at these interviews, the researchers began to develop task-inventory questionnaires that were subsequently used to identify the skills, knowledge, and abilities associated with performing in major task areas.

### Mail Survey of Managers and Supervisors

After completing the on-site interviews and developing the task-inventory questionnaires, MPR staff conducted a mail survey of two additional groups of managers. First, research staff surveyed a selected group of managers that were previously interviewed. These respondents were chosen because of their detailed knowledge of the job tasks and skills required of EHM technicians and their experience in hiring these employees. A second group of managers was selected to represent departments at DOE facilities that employ EHM technicians and related workers where we did not conduct on-site interviews and at private companies with environmental workers.

These two groups of managers received survey forms that reflected the results of the intensive interviews. Specifically, study staff used the interviews to identify an initial list of job skills, knowledge, and abilities (SKAs) for EHM technicians and related workers. The survey respondents were then asked to rate the importance of each SKA on the list—using a Lickert-type scale—in terms of its importance for job performance. We received 128 responses to our survey from representatives at the DOE and private firms. The "Work Force and Skill Requirements of EHM Technicians: Findings from an Employer Survey" section (p. 67) of this report presents detailed results of this survey, including assessments of important job skills and labor market supply and demand patterns.

### Mail Survey of Environmental Technician Educators

The final data-gathering activity in the project involved surveying program coordinators and instructors in a national sample of two-year postsecondary environmental programs. The objectives of the survey were

- to assess the correspondence between skill requirements for EHM technicians that were previously identified by employers and the curricular emphases of hazmat educational programs;
- to compare the types of EHM programs that employers need with those offered by educational institutions;
- to gather information on recruitment, enrollment, and placement trends in these programs;
- to obtain educators' evaluations of current and anticipated labor market conditions for new graduates of environmental programs; and
- to identify the characteristics of students who are enrolled in environmental programs.

Using the same list of skills, knowledge, and abilities that appeared on the survey of employers, educators were asked to rate the importance of these items as components of their curricula, based on a Lickert-type scale. We mailed the survey to representatives of 166 postsecondary institutions (80% were community colleges) and received responses from ninety-four institutions. The "Education's Response to Industry Needs: Findings from a Survey of Community College Educators" section (p. 106) presents the results of this survey and an evaluation of the correspondence between employer needs for EHM technicians and the curricula and types of environmental programs currently offered by two-year postsecondary institutions.

## BACKGROUND: SOURCES AND DIMENSIONS OF THE ENVIRONMENTAL PROBLEM

### Introduction

During the last twenty-five years, a surge in environmental activism has developed in the United States. Supporters of this environmental movement have used a variety of legislative and social action tactics to highlight the magnitude of ongoing destruction to the environment. For instance, they have argued for stricter regulation and have demanded changes in behavior by individuals, public agencies, and corporate entities in order to protect and restore the environment. As a result of these efforts, as well as to growing media attention, many health hazards and risks to the environment have been identified, and a variety of local, state, and federal agencies and programs have been established to minimize and clean up environmental pollution.

Like many social movements, this environmental activism has emerged suddenly. However, it is a response to problems that have been developing for many decades, although the problems' impact has worsened in recent years. Industrial growth during the post-World War II era was unparalleled in American history (U.S. Environmental Protection Agency [EPA], 1988, p. 3), and that growth created a rapid increase in the amount of unregulated industrial waste. At the same time, the proliferation of nuclear weapons and the emergence of the nuclear power industry created the new and difficult problems of managing radioactive material and disposing of radioactive wastes. Because there were insufficient laws to monitor and regulate these by-products of industrial growth, the environment suffered from the burdens of toxins, pollutants, and waste.

To present the complex environmental problem that underlies this research—and that will shape the future need for an environmental work force—this section provides a description of the major sources and types of environmental contamination, including their industry origins, and the scope of current activities to clean up the environment. Understanding the sources of environmental pollution is an important prerequisite to identifying the sectors of the economy where the environmental work force will be employed. This section begins with a brief description of the key agencies and organizations that are responsible for monitoring and controlling environmental pollution. Along with private industry, these agencies will continue to be major employers of environmental personnel.

## Entities Responsible for Environmental Cleanup

### The Environmental Protection Agency

The nation's primary environmental monitoring organization is the Environmental Protection Agency (EPA). This agency was created in 1970 as a federal response to perceptions of a growing environmental crisis. Shortly thereafter, other public entities joined this effort, and coordination between the EPA and local and state governments has enhanced the EPA's ability to identify and resolve problems. The EPA's accomplishments have been many, including the cleanup of thousands of miles of polluted rivers, lakes, and estuaries; the reduction of chemical pollutants in urban air; the improvement of municipal sewage systems throughout the nation; and the monitoring of and restrictions on various pesticides and toxic chemicals.

Despite the obvious successes of the EPA in the last two decades, many environmental problems still need to be resolved. Some analysts, even within the EPA, suggest that the United States has barely begun to address the overall environmental restoration and protection agenda (U.S. EPA, 1988, p. 5). Compounding this situation, as each day passes, additional environmentally hazardous materials, which also need to be handled and disposed of properly, are being produced.

### Other Federal Agencies with Cleanup Responsibilities

More recent federal responses to the need for environmental cleanup have come from the DoD, DOE, and various other federal agencies. These agencies have instituted comprehensive internal departmental controls to comply with expanding environmental legislation (U.S. General Accounting Office [GAO], 1986, p. 2) and to address their own recently recognized and pervasive environmental problems.

Facilities under the authority of these federal agencies represent a major dimension of the environmental cleanup problem. Of these sites, the DoD is responsible for nearly ninety percent, while the DOE is responsible for five to eight percent. The Federal Agency Hazardous Waste Compliance Docket recognizes thirteen other government agencies with potentially hazardous facilities (U.S. Congressional Budget Office [CBO], 1990, p. 14).

A report prepared by the U.S. CBO (1990) identified more than 9,000 potentially hazardous waste sites for which the federal government is liable. Federal agencies currently own and manage 2,300 of these sites. An additional 7,100 sites are properties formerly owned by federal agencies for which they are still liable. Many of these federal sites present serious potential hazards. As of July of 1991, the EPA's National Priorities List (NPL), a listing of the most hazardous uncontrolled waste sites, included 116 federal facilities. This number accounts for nearly ten percent of the total number of national NPL sites.

### *Department of Defense*

The DoD is responsible for a major cleanup program that could potentially include remediation at more than 8,000 military sites (U.S. CBO, 1990, pp. 15-16), with Congress allocating billions of dollars for cleanup of military installations in the years to come. In 1985, the DoD estimated that their overall cleanup project could cost $10 billion (U.S. GAO, 1985, p. 2). Current GAO estimates dwarf past ones in comparison. For example, official figures now project costs to the DoD in the range of $40-$200 billion with a potential $5 billion expenditure for one Indiana site alone, the Jefferson Proving Ground (Schneider, 1991, p. C-3).

### *Department of Energy*

Although the number of contaminated DoD sites far exceeds those at DOE locations, the DOE faces an even more costly project in the cleanup of hazardous and radioactive wastes at their facilities. DOE facilities represent the federal government's most serious and costly contamination problem (U.S. CBO, 1990, p. 13). Responding to the magnitude of this challenge, the DOE has established an agenda, its Five-Year Plan, to address the management of hazardous waste, both past and present. The agency has set a thirty-year goal for the complete restoration of the environment at their facilities. In addition, all dysfunctional aspects of the DOE's hazardous materials operating activities shall be discontinued (U.S. DOE, 1989a, p. 4).

The overall cost of the DOE's environmental cleanup project could possibly exceed $300 billion. The General Accounting Office (GAO) reports that the agency's expectations of both project duration and financial requirements may be seriously underestimated (Schneider, 1991, p. A-1). Last year, the GAO's conclusions were at least partially confirmed when the DOE announced that a $12 billion budget gap is expected for their cleanup program during the next five years ([*New York Times*], 1991, p. A-3).

**Private Entities and State and Local Government**

Private industry, state governments, and municipal districts also face significant hazardous waste problems. These entities are responsible for slightly more than ninety percent of the total number of sites listed on the EPA's NPL, as of the July 1991 update (U.S. EPA, 1991b). In 1989, the GAO estimated that the average cost of remedial actions at each Superfund site ranged between $21 million and $30 million (U.S. GAO, 1989, p. 12). Multiplying these cost estimates by the 1,200 sites listed on the NPL leads to an estimate of up to $36 trillion for the total cleanup effort. In addition to these 1,200 NPL sites, the GAO reports that as many as 130,000 to 425,000 other sites may require evaluation for further cleanup action. Non-NPL sites include those that the EPA has found ineligible for the NPL, those that have not yet been assessed, and those sites that have not yet been reported or discovered.

Despite the fact that many of these sites are not listed on the NPL, they do present significant hazards. The Hazardous Ranking System (HRS) scoring cutoff for NPL eligibility, originally created by the EPA, was arbitrarily set at 28.5 on a 100-point scale so that it would include roughly 400 sites. As a result, there are many non-NPL sites with scores just below the cutoff point that still present a significant hazard (U.S. GAO, 1989, pp. 12-13). Because these sites are not listed on the NPL, they are not eligible for Superfund money. Consequently, private, local, and state entities will be responsible for financing cleanup and response activities.

Although they are highly imprecise and constantly changing, all these cost estimates for future environmental cleanup activities clearly indicate that the effort will be significant. There are many variables in the equation that will determine expenditures on environmental cleanup. For example, the unique problems and cleanup requirements of the DoD, DOE, other government agencies, and the private sector will dictate the pace of cleanup activities, the types and numbers of personnel required to accomplish these efforts, and the ultimate program costs.

### Sources of Environmental Contamination

Damage to the environment results from a wide array of sources, many of which are regulated under various pieces of federal legislation. This environmental damage results from activities in distinct industries and often presents unique hazards. Different types of contamination also require the use of unique monitoring and cleanup technologies. As a result, the numbers, types, and skills of personnel required to perform hazardous materials handling and cleanup activities are heavily influenced by the source or type of environmental contamination.

For the purposes of this study, we have classified environmental contaminants into the following general categories:

- radioactive wastes
- industrial wastes
- municipal wastes
- biomedical wastes
- other solid wastes, including mining and agricultural wastes

#### Radioactive Wastes

Radioactive wastes are the by-products of many industrial and military-related activities. They are typically categorized into four major groups that are defined by differences in toxicity, methods of disposal, and sources and types of regulation (Lin, 1991, pp. 373-393).

- *High-Level Wastes (HLW)* are those materials resulting from the reprocessing of spent nuclear fuel. For legislative, political, and economic reasons, fuel reprocessing is not currently an ongoing activity in the United States. Consequently, the volume of HLW is stable. More than ninety-five percent of all existing HLW is under the jurisdiction of the DOE; these wastes result from DOE's defense-related activities. Since no other alternative disposal options exist, the DOE has been forced to store these highly radioactive wastes on-site. However, Congress is currently developing a solution to the build-up of these wastes at DOE facilities (discussed in the next section).

- *Spent Nuclear Fuel (SNF) Wastes* are the depleted fuels discharged from nuclear reactors. Nearly ninety percent of these wastes result from the activities of commercial nuclear power plants, where the wastes are currently stored. With the ban on SNF reprocessing that has been in effect since 1977, these stored wastes also await alternative disposal. Moving toward an alternative disposal method for both HLW and SNF, Congress passed the Nuclear Waste Policy Amendment Act (NWPAA) in 1987 to create a deep geological repository for permanent disposal. However, political wrangling and conflicting views about the best long-term storage strategy have delayed the site selection and construction of this repository.

- *Transuranic (TRU) Wastes* include those wastes that are still highly radioactive but are not HLW or SNF. Types of TRU wastes include contaminated equipment used in the reprocessing of SNF, effluent sludges, and other materials. The largest portion of TRU waste volume has come from defense-related activities. It has been estimated that nearly 200,000 metric tons of TRU are in shallow burial sites at DOE facilities. Only 62,000 tons of this material are in retrievable storage.

- *Low-Level Wastes (LLW)* are all those wastes that are not classified under the other three categories although they still have hazardous radioactive content. Included in this category is the large volume of contaminated clothing, instruments, and equipment that has been produced at defense facilities. LLW are defined as less toxic and hazardous to health and the environment than are the previous categories. These low-level wastes account for the largest portion of radioactive waste volume, more than eighty percent. However, LLW represent only two percent of overall radioactivity. LLW are created by various entities, including medical institutions and research and development (R&D) facilities.

A small portion of LLW are mixed wastes (MW), which are radioactive wastes that also have other hazardous contents. These mixed wastes are regulated by the RCRA of 1976 (RCRA) but only "to the extent that [the RCRA] is not inconsistent with the [Atomic Energy Act]" (U.S. DOE, 1989b, p. 4). Disposal of LLW and MW is regulated under the Low-Level Radioactive Waste Policy Act (LLRWPA) of 1980 and its amendments of 1985, which requires each state to establish its own LLW and MW disposal facilities or to join into a regional compact to create cooperative LLW management programs. However, several years after the LLRWPA was passed, many states still had not constructed their own disposal sites. According to Lin (1991, pp. 387-389), nine such regional compacts existed by 1991. The high social and economic costs of these construction projects have created a need for increased interstate cooperation.

### Industrial Hazardous Wastes

Hazardous wastes also result from many industrial activities occurring in manufacturing and processing firms of all sizes. The EPA estimates that about 275 million metric tons of industrial waste are generated each year. The large volume of these wastes—unregulated until 1980—was the major impetus behind the passage of the Comprehensive Environmental Response, Compensation, and Recovery Act of 1980 (CERCLA). This legislation established the national Superfund Program, which implements the Congressional mandate to clean up existing uncontrolled hazardous waste sites. In addition to CERCLA, which regulates industrial waste cleanup activities, the Resource Conservation and Recovery Act (RCRA) regulates the ongoing management of these materials (U.S. EPA, 1988, pp. 80-85).

By regulation, the characteristics of industrial waste that can be used to define it as hazardous are ignitability, corrosivity, reactivity, and toxicity. The chemical and petroleum industries are the largest contributors to this category of waste, with chemical manufacturers alone contributing seventy-nine percent of all industrial hazardous waste (U.S. EPA, 1988, p. 80).

Toxic chemicals are a substantial component of the hazardous elements in industrial wastes. These chemicals are used in the manufacturing processes of many products, including pharmaceuticals, food products, construction materials, detergents, metals, paper, and countless others. Without chemicals we would not be able to create many of the technologically advanced products that are integral parts of modern life.

However, many toxic chemicals can also create serious health hazards ranging from mild irritations to fatal cancers. The types of materials in this category include insecticides, PCBs, CFCs, and other harmful chemical compounds. The regulation and control of these substances is authorized under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act of 1947 (FIFRA) and the Toxic Substances Control Act of 1976 (TSCA) (U.S. EPA, 1988, p. 113).

### Municipal Wastes

One of the most diverse of these categories, municipal wastes include both commercial and household wastes that have accumulated over many years and continue to be dumped at municipal landfills. A small portion of these wastes such as solvents, cleaning fluids, and battery acids are very hazardous. Unfortunately, these hazardous substances are difficult to detect because they are intermingled with the other nonhazardous sludge and waste. Therefore, municipal wastes are labeled "quasi-hazardous" because they have the potential to become hazardous through improper management. For example, rainwater running through a faulty disposal facility can cause contaminated leachate to reach ground water supplies.

Currently, an overwhelming majority of municipal wastes are being disposed of in landfills. Because of their low levels of toxicity, municipal wastes have not been regulated by the RCRA. Consequently, the Water Quality Act of 1987 (WQA), which provides for alternatives to land disposal of municipal sludge, has been one of the few regulations reducing the toxic effects of municipal waste (U.S, EPA, 1988, pp. 80-90). More recently, the EPA announced national standards to control leakage from municipal landfills. These rules require landfill operators to monitor groundwater and to detect leakage of lead, plastics, or other chemicals into the water (Pear, 1991, p. A-1).

### Biomedical Wastes

Over the past few years, biomedical wastes have become a growing problem. Medical debris washing up on the shores of the Northeast during the summers of 1987 and 1988 first aroused widespread public concern over the proliferation of such wastes. At least some East Coast beaches now experience intermittent closures every summer because of biomedical contamination. The public's major fear is that these wastes could be infectious, carrying diseases such as hepatitis B or Human Immunodeficiency Virus

(HIV). Biomedical wastes can originate from a variety of sources, including hospitals, health care facilities, laboratories, dental and medical offices, funeral homes, and veterinary hospitals.

The EPA has classified biomedical wastes into the following categories: (1) microbiological wastes such as cultures of infectious agents; (2) liquid blood and blood products; (3) isolation wastes from patients with communicable diseases; (4) pathological wastes such as body tissues and organs; (5) used sharps such as needles and scalpels; and (6) contaminated animal carcasses, body parts, and bedding. The EPA estimates that hospitals produce roughly three-quarters of all biomedical wastes, which can reach a volume of 3.2 million tons per year (U.S. GAO, 1990, pp. 2-9).

In 1980, infectious wastes were purposely withheld from regulation under Subtitle C of the RCRA because they were not considered to pose a substantial hazard to human health and the environment. Consequently, infectious wastes were left to the regulation of the states. In light of the incidents that occurred in 1987 and 1988, the EPA and Congress began to reconsider their prior positions. In 1988, Congress passed the Medical Waste Tracking Act that established a two-year program to monitor and select a federal tracking system for the future regulation of such wastes (U.S. GAO, 1990, pp. 10-13).

### Other Solid Wastes

In addition to the categories of waste described above, other types of waste are widely dispersed in the environment, and these can sometimes be viewed as hazardous. Most noteworthy are the more than 5.5 billion tons of agricultural and mining wastes produced annually. These wastes are not considered hazardous by definition. However, because of the tremendous quantities generated each year, there is significant potential for environmental harm. Even the low levels of toxicity in these wastes can create a much greater environmental threat when multiplied by millions of tons. For example, the resulting leachate and runoff from huge waste dumps can contaminate water supplies (U.S. EPA, 1988, pp. 79-81).

## Scope of the Environmental Issue

### Current Environmental Waste Management Activities

This section briefly describes the scope of necessary environmental cleanup and compliance with government regulations, including an overview of past activities and an assessment of future challenges. The discussion provides a foundation for understanding the factors that are driving the demand for environmental personnel and the need for trained technicians to help accomplish the nation's environmental agenda.

Several ongoing activities are intended to restore our environment and promote waste management and reduction.

***Restoration***

- *Remediation*: Cleanup of previously existing waste and pollution.
- *Corrective Activities*: Bringing facilities into compliance with state and federal regulations.

***Waste Management and Reduction***

- *Waste Treatment and Management Activities*: Management of ongoing operations that produce hazardous wastes, including required treatment of wastes before disposal or incineration.
- *Source Minimization and Recycling*: Reduction or deletion of processes that create waste and pollution.
- *Disposal*: Implantation of wastes in aboveground and underground structures within the limitations of the HSWA Land Disposal Restrictions.
- *Monitoring*: Efforts to detect contaminants of concern.
- *Transportation*: Movement of hazardous wastes and materials to other locations, usually for treatment, disposal, or storage.
- *Emergency Response*: Preparation for toxic and chemical emergencies, which is mandated by Congressional legislation.

The next sections address each of these activities as they apply to the three types of pollution that are covered by major environmental legislation: land pollution/solid waste disposal, air pollution, and water contamination.

## Land Pollution/Solid Waste Disposal

### *History*

The American public began to recognize the hazards associated with land disposal of solid waste in the early 1970s. As a result of decades of unregulated land disposal, uncontrolled hazardous waste sites became numerous and widespread. These uncontrolled hazardous waste sites have significant potential to exacerbate environmental problems other than soil contamination such as air and water pollution. Because the problems of land disposal have only been uncovered in the last few decades, additional research on containment methods and related issues is necessary. One of the greatest environmental challenges remaining in the near future is creating alternatives to past practices of solid waste ground disposal.

As defined by Congress, solid wastes are not confined to solid substances and may include liquids, sludge, and contained gases (U.S. Congress, 1987, p. 7). Additionally, solid wastes can refer to both hazardous and nonhazardous substances (U.S. National Archives Records Administration, 1991, pp. 27-33). For the purposes of this study, our focus is only on hazardous wastes, which are defined as those materials that present a substantial threat or have the potential to threaten the environment or human health adversely (U.S. CBO, 1990, p. x). Hazardous solid wastes are created as the by-products of many processes, from nuclear weapons production and industrial manufacturing to dry cleaning. The amount of hazardous waste produced each year ranges into the hundreds of millions of tons (U.S. EPA, 1988, p. 85).

Recognizing the scope of problems resulting from the disposal of solid wastes and the diverse content of solid waste, Congress has passed a number of legislative bills to begin controlling the situation.

- The Atomic Energy Act (AEA) of 1954 established regulations for the handling of radioactive materials, and the Nuclear Waste Policy Act (NWPA) of 1982 established a comprehensive national program to deal with the disposal of radioactive solid waste (U.S. CBO, 1990, p.11; Meyers, 1986, p. iii).

- The Resource Conservation and Recovery Act of 1976 (RCRA), the first major bill regulating the handling of solid waste, was intended to control and manage hazardous wastes (U.S. CBO, 1990, p. 10).
- The Comprehensive Environmental Response, Compensation, and Recovery Act of 1980 (CERCLA) was the first effort at a coordinated national response program to manage existing uncontrolled hazardous waste sites (U.S. Congress Congressional Research Service [CRS], 1991, p. 61).

The AEA and RCRA provided the guidelines by which hazardous wastes must be managed, while CERCLA and NWPA created systems to dispose of previous wastes. In addition, CERCLA created the National Priorities List (NPL), which currently identifies the most hazardous waste sites in the nation. Using the CERCLA "Superfund," the EPA must investigate and enforce cleanup regulations at these NPL sites (U.S. CBO, 1990, p. 11).

### *Current Challenges*

#### *Environmental Restoration/Corrective Activities*

Until recently, most of the public and legislative initiatives concerning environmental hazards focused on the management and control of hazardous materials and waste. It was not until the passage of the CERCLA in 1980 that Congress finally established a program to clean up hazardous waste contamination from past disposal activities (U.S. CBO, 1990, p. 11). By then, tens of thousands of potentially hazardous waste sites existed within the United States (U.S. EPA, 1988, p. 93). The CERCLA established a tax based primarily on oil and chemical products that provides the Superfund (U.S. Congress CRS, 1991, p. 62) with financial resources to respond to releases of hazardous materials both in short-term emergencies and long-term projects (p. 63). The NPL identifies the nation's most uncontrolled waste sites according to the Hazard Ranking System (HRS), and as of January 1991, a total of 1,197 sites were included on this list (p. 64). These sites are considered the most dangerous among many thousands of potentially contaminated hazardous waste sites recognized by the EPA.

Under Congressional mandate, the EPA is required to monitor such uncontrolled hazardous waste sites and to coordinate the restoration of those on the NPL. Responsible parties are liable for cleanup costs and damage to natural resources. In addition, triple punitive damages may be imposed on those responsible parties who fail to cooperate in the cleanup efforts (U.S. Congress CRS, 1991, p. 64). Unfortunately, many of the potentially responsible parties (PRPs) avoid the EPA's efforts to impose fines, which has produced a difficult fiscal situation for the EPA. Although the agency is attempting to coordinate cleanup efforts, provide the necessary funds during the interim period, and retrieve funds from the PRPs, the EPA has been forced to spend considerable sums of money on legal battles with the PRPs. Thus, significant resources intended for the cleanup projects have been diverted to judicial fights, with the number of sites having undergone successful restoration falling far below expectations. In fact, as of 1988, only about one hundred fifty Superfund site cleanups had been initiated (U.S. EPA, 1988, p. 95), and as of July 1991 only 34 sites of the entire pool of 1,211 had been totally remediated and deleted from the NPL (U.S. EPA, 1991b, pp. 1-6).

Under the authority of CERCLA, contaminated federal facilities are subject to the same cleanup requirements as other waste sites. However, federal agencies are not eligible for the Superfunds and, therefore, must use their own congressional appropriations for cleanup. The estimated costs to the federal agencies for the cleanup could easily exceed $150 billion (U.S. CBO, 1990, p. ix). Considering the yearly appropriations for each agency, it is unlikely that these cleanups will occur immediately.

- ***Underground Storage Tanks***

  Despite the limited attention directed toward underground storage tanks until recently, they do pose a significant threat to the environment and human health. Currently, there are between five and six million of these tanks in use, representing a major potential hazard (U.S. EPA, 1988, p. 102). The Hazardous Solid Waste Amendments to the RCRA of 1984 (HSWA) addressed the problem of underground storage tanks on the national level for the first time, requiring registration of all existing and new tanks, use of alternative tank design, and cleanup of any tanks with leaks (U.S. Congress CRS, 1991, p. 56). The Superfund Amendments Reauthorization Act of 1986 (SARA) allocated a $500 million portion of the Superfund specifically for cleanup of these tanks (U.S. Congress CRS, 1991, p. 62). As with other aspects of environmental cleanup, the

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EPA has enlisted the help and leadership of state governments to gain control over this problem by implementing local tank removal and monitoring programs.

The immense number of underground tanks presents a major challenge for the EPA—with the monitoring and registration of these tanks in addition to cleanup and removal of leaking tanks—creating tremendous costs. Most of the tanks already in the ground are constructed of unprotected bare steel, which has a natural tendency to rust and corrode (U.S. EPA, 1990, p. 104). Thus, most of these tanks eventually will leak and need replacement. New technologies now exist that will virtually eliminate the possibility of corrosion, but existing steel tanks must be replaced before they create any further damage.

- ***Small Quantity Generators***

  The inclusion of small quantity generators (SQGs) in the hazardous waste regulatory process occurred in 1984 under HSWA. These generators are defined as ones that create less than one thousand kilograms of hazardous waste per month (U.S. Congress CRS 1991, p. 56). In a recent report completed at the University of California at Davis that examined the problem of illegal waste disposal by SQGs, it was found that SQGs are major contributors to environmental contamination because they are more likely than are large generators to dispose of their wastes illegally.

  Many of these SQGs are dry cleaners and auto repair shops that are heavily concentrated in metropolitan areas. Consequently, their pollutants pose a greater risk to human health because of their close proximity to large populations (Schwartz, Cuckovich, Cox & Ostrom, 1989, p. 281). Although it is clear that the problem is significant, insufficient information is available on this subject to estimate the potential risks and hazards of SQGs. Nevertheless, the huge number of SQGs (roughly 100,000) suggests that future efforts will likely be directed at additional regulation and monitoring of these establishments.

### *Ongoing Management Requirements*

Until the passage of the RCRA in 1976, the United States had no comprehensive policy for the management of hazardous wastes (U.S. EPA, 1988, p. 85). This act sets guidelines for the generation, handling, and disposal of hazardous solid wastes but does not cover nonhazardous and quasi-hazardous wastes. However, it is important to recognize that these solid wastes can easily become hazardous contaminants in the environment as a result of improper disposal. When solid wastes are mismanaged, toxic gases may form and contaminate the air and water or may create a potentially explosive hazard. Leaking disposal sites can also cause toxic seepage into water supplies (pp. 86-87). Therefore, because of their similar hazardous potentials, both hazardous and quasi-hazardous solid wastes are grouped together throughout this report.

The RCRA and its amendments were created to minimize the risks of handling and disposing of hazardous waste by instituting a "cradle to grave" management approach designed to cover the waste from its inception to its disposal (U.S. EPA, 1988, p. 88). The EPA requires permits for all handlers of hazardous waste and enforces the regulations through penalties. In 1984, the RCRA was strengthened through passage of the Hazardous Solid Waste Amendments (HSWA). This new legislation implemented a "land ban" on the disposal of all wastes that do not meet certain safety requirements, greatly altering solid waste management. In addition, the HSWA increased the number of waste generators included under RCRA supervision from 15,000 to 115,000 and created a new program for the regulation of underground storage tanks (U.S. Congress CRS, 1991, p. 56).

## Air Pollution

### *History*

The most extensive efforts to cleanup and protect the environment have been made in the area of air pollution. Because some airborne pollution is readily visible, the public responded as early as the 1950s to its dangers. Since the Clean Air Act of 1963, the United States has made considerable progress in improving the quality of air nationwide. This act set standards for airborne pollutants and subdivided them into two categories: *criteria pollutants*, ones that threaten air quality, and *hazardous pollutants*, ones that pose a threat to human health.

The EPA recognizes two main sources of air pollution. First, mobile sources include cars, buses, boats, and aircraft. These sources are responsible for more than one-half of the nation's air quality problems. Second, stationary sources include industrial and municipal plants, refineries, gas stations, and dry cleaners. These sources produce pollution mainly by burning fuel for energy and as by-products of industrial processes.

In 1977, the EPA began imposing regulations on mobile source pollutants through the Federal Motor Vehicle Control Program. Placing restrictions on the amount of lead in gasoline severely reduced the ambient levels of lead in the air. Between 1977 and 1986, lead levels declined by eighty-seven percent and lead emissions by ninety-four percent (U.S. EPA, 1988, p. 14). Regulating the auto industry also reduced ambient levels of carbon monoxide by thirty-two percent, ozone by thirteen percent, and nitrogen dioxide by fourteen percent. The EPA also reduced pollutants from stationary sources, but to a lesser extent. In addition, the installation of pollution control equipment in industrial factories reduced airborne particulates by twenty-three percent. Finally, controls at coal-fired power plants cut levels of sulfur dioxide by one-third (p. 15).

As a result of these efforts during the past fifteen years, ambient levels of lead, carbon monoxide, sulfur dioxide, nitrogen dioxides, ozone, and airborne particles have been reduced dramatically (U.S. EPA, 1988, p. 12). However, despite these significant achievements in reducing air pollutants, important problem areas remain. Although the criteria for acceptable amounts of pollutants have been set by the EPA, there are still regions in the country where the levels are above the allowable limits. For example, ozone levels are above the allowable level in more than sixty urban areas (p. 16). In addition, the EPA recognizes seven other areas of concern that represent serious challenges to compliance with pollution standards: carbon monoxide, airborne particulates, sulfur dioxide, airborne toxins, acid deposition, indoor pollution, and radon.

### *Current Challenges*

#### *Management Activities/Source Minimization*

- ***Ozone***

  In the upper atmosphere, ozone is natural and necessary to life. However, in excessive amounts, it is unnatural and harmful. Ozone presents a serious health hazard because it breaks down biological tissue. It is created when sunlight causes chemical reactions to occur between natural gases and volatile organic compounds (VOCs) such as combusted petroleum products (U.S. EPA, 1990, p. 18). Because of the problems associated with densely populated modern urban

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areas, it is difficult to reduce ozone to acceptable levels. Although regulations have limited the amount of combusted fuel emissions from each vehicle, there is no currently acceptable method of enforcing limits on the number of cars on the road. With the growth of urban populations, ozone pollution continues to rise.

- ***Carbon Monoxide***

  An odorless, invisible gas, carbon monoxide can have very harmful effects on humans when inhaled. Motor vehicles emit most of the carbon monoxide in our environment, but it also arises from wood stoves, incinerators, and industrial processes. Like ozone, there has been limited success in reducing carbon monoxide emissions in urban cities whe[illegible]ivate vehicle traffic is increasing or remaining steady. In addition to these [illegible] analysts estimate that twenty percent of all vehicle owners tamper with [illegible]ssion control devices (U.S. EPA, 1988, p. 20). If it were possible to monitor these regulations effectively, provide incentives for compliance, or create alternative modes of transportation, then there would be a substantial decrease in VOCs and carbon monoxide.

- ***Airborne Particles***

  Varying greatly in size and make-up, airborne particles can be as harmless as dust or as hazardous as toxic chemicals. The main sources of airborne particles are industrial mills, power plants, diesel engines, and construction work. Windblown areas are most prone to such pollutants.

  While standards have been set for processes that create particles, there is no clear policy for regulating the smallest particulates, those as small as ten microns. Because they can remain lodged in the lungs for quite a long time, the smallest are the most dangerous. Simple filters are not capable of collecting such small particles. The future development of more stringent EPA policy will depend on the manufacture of new, innovative devices to prevent the release of such particles into the air. One example of such a device is an electrically charged plate that attracts particles like magnets.

- ***Airborne Toxins***

  These toxic chemicals are becoming a serious threat to human health because of their many modes of conveyance. Humans can be directly exposed to airborne toxins through inhalation, or they may consume toxins through the food chain and drinking water. Many toxic chemicals accumulate most readily in fatty tissues and breast milk (U.S. EPA, 1988, p. 25). Airborne toxins are emitted from various sources, including industrial factories, waste and sewage plants, incinerators, and metal refineries. The EPA regulates these polluters through the National Emission Standards for Hazardous Pollutants (NESHAPs), which regulates toxic chemicals such as mercury and carcinogens such as asbestos.

Currently the EPA is uncertain about the hazardous potential of many chemicals such as ammonia and formaldehyde. Additionally, no clearly defined national program exists to address and regulate these toxins. Instead, the EPA works with individual state governments to help them create their own regulatory system to monitor these toxic chemicals (U.S. EPA, 1988, pp. 23-24). Analysts predict that in the next decade the chemical industry will grow at a substantially greater pace than other industries, potentially increasing the volume of existing and new chemical toxins that are dispersed into the air.

### *Sulfur Dioxide*

Although simple sulfur dioxide can represent a substantial health hazard on its own, it can present an even greater environmental hazard when it is converted into sulfuric acid through oxidation and subsequent reaction with water vapor. Sulfur dioxide emissions that are turned into sulfuric acid are the principal contributors to acid rain (U.S. EPA, 1988, p. 26). Until 1970, large quantities of sulfur dioxide emissions were released by industry and coal-fired power plants. However, since the establishment of the EPA, efforts to control these emissions have achieved some success.

The EPA has enforced its regulations by imposing new recycling and management activities. For example, many industrial firms have developed emission control systems or have converted their sulfur dioxide into other acceptable emissions. The major challenges remaining to reduce sulfur dioxide emissions are the result of coal-fired power plants, which account for two-thirds of all national emissions (U.S. EPA, 1988, p. 26). These plants present a serious challenge because coal is the major U.S. power source for generating electricity.

- ***Radon***

  This gas poses a unique problem because radon is a naturally occurring gas that enters houses and buildings through cracks in foundations. When inhaled, radon can cause serious radiation damage to the lungs. It is estimated that this gas claims as many as five to twenty thousand lives a year (U.S. EPA, 1988, p. 35). The EPA has taken a nonregulatory approach to helping citizens reduce their risk of exposure to radon while at home. For instance, they have gathered monitoring techniques that have been created and implemented by local governments and have made this information available to the public.

## Water Contamination

### *History*

Under the mandate of the Clean Water Act of 1972 (CWA), the EPA has been given the authority to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (U.S. EPA, 1988, p. 45). As in the field of air pollution, the EPA is involved in partnerships with state and local governments to solve the problems of water contamination.

The contamination of our nation's water can be divided into three areas: drinking water, near coastal waters, and free-flowing surface waters. Water pollution stems from four pollution sources: municipal, industrial, nonpoint, and dredge activities (U.S. EPA, 1988, p. 46):

1. *Municipal wastewater* is defined as that which emanates from household sewage systems. Sometimes household toxic chemicals as well as organisms and bacteria that accumulate in storm drains can be found in municipal wastewater.

2. *Industrial wastewater* is similar to municipal wastewater but includes more contaminants such as heavy metals, synthetic substances, and other toxins.

3. *Nonpoint sources* refer to wastewater that cannot be traced to a particular place of origin. Nonpoint wastewater acquires pollutants from various phenomena, for example, rainwater washing through polluted farmlands.

4. *Dredge activities* refer to the widening and deepening of waterways. These processes stir up sediment such as PCBs and heavy metals from the bottom of the water and carry them along in the current.

To date, the EPA and the states have been successful in cleaning up and protecting the nation's water systems. In the last decade, the EPA has increased the number of monitored water supplier systems to 58,000, three times the number monitored before 1969. Of these water suppliers, nearly ninety percent comply with the standards established by the EPA's Maximum Contaminant Levels (MCLs). In addition, new management systems have been implemented to protect the aquatic life at numerous rivers, fresh-water lakes, and seashores. As a result of the regulations of the EPA, many thousands of miles of rivers and streams have been reclaimed to acceptable pollutant levels, and wastewater treatment activities have been greatly improved (U.S. EPA, 1988, pp. 48-49).

Despite these extensive achievements in protecting the water supply, many old and new problems need to be addressed. For instance, groundwater is being contaminated by leaking underground waste storage tanks. Hazardous and radioactive wastes are contaminating the soils at more than one thousand NPL sites. Finally, many beaches are being threatened by shoreline pollution and hazardous waste spills, and marine life is being threatened by bacteria, PCBs, and other industrial wastes. In order to protect the nation's water systems, an effective and comprehensive solid waste management program must be maintained.

### *Current Challenges*

#### *Source Minimization/Monitoring*

- ***Drinking Water***

  An enormous amount of ground contaminants must be controlled in order to minimize potential contamination of ground-water supplies by leachate. This is an immense task considering the millions of public and private facilities in the United States with potential contaminants. The EPA recognizes 29,000 hazardous waste sites; potentially faulty septic systems in one-quarter of all U.S. homes; more than 180,000 surface impoundments; more than 16,000 landfill and waste disposal facilities; approximately five to six million underground storage containers, which have significant leakage potential; thousands of underground waste injection wells; and billions of pounds of agricultural pesticides and fertilizers used annually, which can leach into the water supply (U.S. EPA, 1988, p. 52).

The EPA has listed several contaminants that are of special concern to public health because they affect our nation's drinking water supplier systems:

- Lead is a hazardous element found primarily in corroded plumbing. Some environmental analysts have argued that physiological problems, especially neurological damage, stemming from the ingestion of lead in drinking water have been evident, particularly among children.
- Radionuclides are radioactive isotopes that occur naturally in groundwater drinking systems. Toxins of this type, such as uranium and radium, may cause cancer after exposure.
- Microorganisms can also pose a potential threat to water systems. In many cases, microbiological contaminants can be completely harmless; yet in other instances, as with parasites and pathogens, they can cause serious diseases.
- Problems related to the great number of small-water supply systems, those that serve between 25 and 3,300 people, also complicate the situation. Even though these smaller systems serve the vast majority of our nation's population, many of them do not comply with national water standards, and many small communities cannot afford to install new water management systems to bring their water supplies into compliance (U.S. EPA, 1988, pp. 57-58).

The EPA will continue on its own to track contaminants that are of national concern. However, because of resource constraints, they will need to develop cooperative agreements with the states to perform needed monitoring activities. Because enforcement of all the MCL standards could be extremely difficult and expensive, priorities in the near future will likely focus on situations that create the highest risk to human health.

- ***Near Coastal Waters***

  These are waters that stretch from the head of the tide toward the inlands but are still affected by the influence of the tides. Thus, they include estuaries, bays, and coastal areas. The EPA has also considered the cleanup of the Great Lakes to be in this category.

  Near coastal waters are not only a crucial part of the rich ecology of marine life but also the lifeline of commercial fishermen. Eighty-five percent of our nation's commercially harvested fish spend some part of their lives dependent on these waters. Unfortunately, these waters suffer from excessive contamination. First, they are subjected to the dumping of industrial and municipal waste from coastal urban cities. Second, they are constantly receiving runoff from nonpoint sources. Third, these waters are subject to constant physical alteration such as dredging, which stirs up sediment and upsets the sensitive marine life. Last, near coastal waters are subject to sporadic releases from sewers and stormwater overflow. The major contaminant problems in these waterways result from toxins and excessive nutrient inputs (U.S. EPA, 1988, p. 65).

  The most serious threat to the future of these near coastal waterways is the estimated future demography of the nation. Projections indicate that by the year 2000, seventy-five percent of the nation's population will live within fifty miles of the coast (including the Great Lakes). Thus, there is great potential for further damage to and pollution of these fragile water systems. The challenge will be for state governments to provide incentives to farmers, industry, and communities to reduce their pollutants into the water system (U.S. EPA, 1988, p. 67).

- ***Surface Waters***

  The contamination of surface waters is similar to that of coastal waters. It results from the discharges of industrial and sewage treatment plants and nonpoint sources that flow into rivers, streams, and lakes. In addition, excessive amounts of phosphate nutrients result in algae-choked water. Unfortunately, the sewage problem has become worse recently, with municipal sludge doubling in volume since 1972 (U.S. EPA, 1988, p. 70).

In order to protect the nation's surface waters fully, many efforts need to be undertaken by the states. For example, efforts to monitor, minimize, and manage the amount of toxins released into the waters must be implemented. Additionally, a new technique for the disposal of sewage sludge must be put into place. Toward this end, recycling, or alternative use of these waste products, may be one of the most effective approaches.

### Geographic Patterns of Industrial Hazardous Waste Production

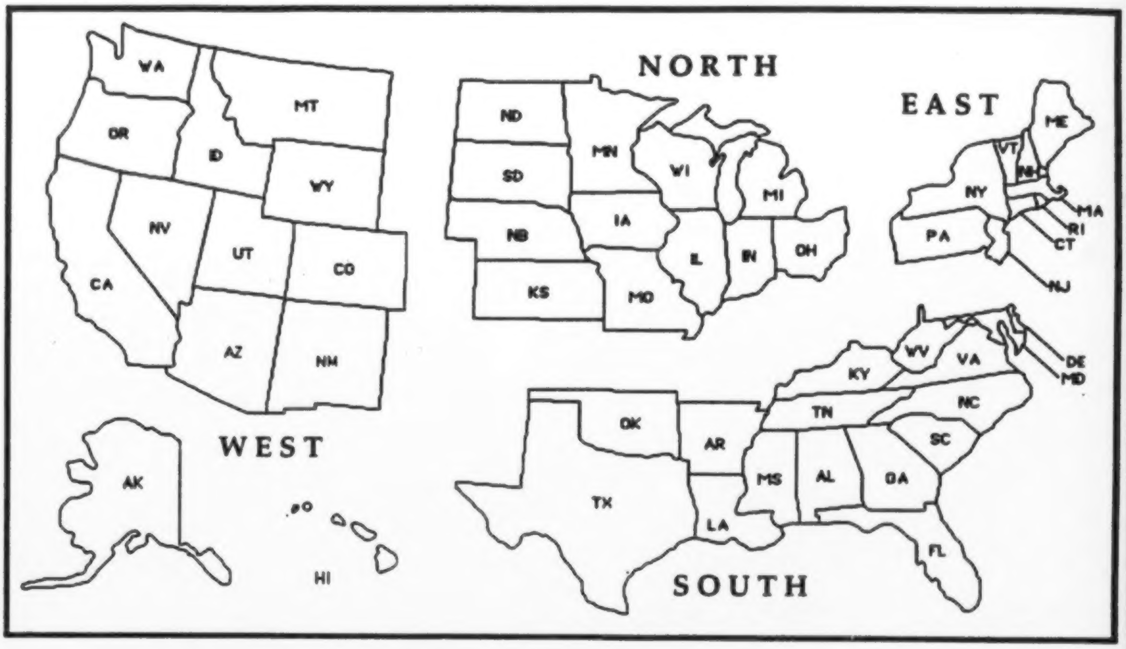
Wherever there are population concentrations some types of hazardous waste are generated. For example, virtually all locations must deal with municipal waste and the by-products of municipal utilities. However, not all regions share equally in various industrial activities. Consequently, in assessing the future need for trained environmental personnel, it is important to understand how the geographic distribution of industries varies and how this affects the demand for environmental workers. Specifically, the concentration of various industries or military activities in certain states or regions of the country will have substantial influence on aggregate levels of local and regional demand for environmental personnel. Similarly, industry location will affect the types of personnel required and the skills they will need.

Various regions of the United States have cultivated particular industries within their boundaries. In many instances, they have done so because they have certain topographical or geological features such as rivers, coal or ore deposits, and particular climates that encourage particular industries. While most industries and human activities create at least some hazardous waste, the discussion that follows focuses only on the major industrial waste producers that require large numbers of environmental workers. The next section provides a description of the geographic distribution of the chemical and petroleum industries, commercial nuclear power plants, and federal facilities that have produced radioactive and mixed waste sites. According to the EPA (1988, p. 80), these four industries account for more than eighty-five percent of nonradioactive hazardous waste and nearly all radioactive waste in the United States.

To describe the locations of the industries that have been major contributors to industrial hazardous waste, we divide the United States into four geographic areas: the

East, North, South, and West. The map below shows the states that are included in each region.

**Figure 1**
**U.S. Regional Map**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### *Chemical Industry*

The EPA recognizes the chemical industry as the largest contributor to industrial hazardous waste. Chemical plants contribute seventy-nine percent of the total U.S. industrial waste, and these plants generate this waste in widely dispersed areas of the country (U.S. EPA, 1988, p. 80). As Table 1 demonstrates, every region includes at least some states with higher than average numbers of chemical manufacturing and/or processing facilities. Even in the West, which has relatively limited production of wastes from chemical processing, California represents an exception.

**Table 1**

**Chemical Industry, by U.S. Region**

| Region | Average Level of Production | States with Higher than Average Regional Production | States with Lower than Average Regional Production |
|---|---|---|---|
| East | Heavy | New Jersey | Maine<br>Vermont<br>Rhode Island<br>New Hampshire |
| South | Moderate to Heavy | Louisiana<br>Texas | Oklahoma |
| North | Moderate | Illinois<br>Indiana<br>Ohio | North Dakota<br>South Dakota<br>Nebraska |
| West | Light to None | California | |

Source: PC Globe, 1990.

### *Petroleum Refining Industry*

According to the EPA, petroleum refining is the second largest contributor to industrial hazardous wastes (U.S. EPA, 1988, p. 80). However, in contrast to the chemical industry, the petroleum industry is more heavily concentrated in a few states and regions, mainly in the South and to a lesser extent in the Far West.

**Table 2**

**Petroleum Refining Industry, by U.S. Region**

| Region | Average Level of Production | States with Higher than Average Regional Production | States with Lower than Average Regional Production |
|---|---|---|---|
| East | Light to None | New Jersey<br>Pennsylvania | |
| South | Moderate to Heavy | Louisiana<br>Texas | Entire Southeastern Seaboard |
| North | Light to None | Illinois<br>Indiana<br>Ohio<br>Kansas | |
| West | Moderate | California | Idaho<br>Oregon<br>Nevada<br>Hawaii<br>New Mexico |

Source: PC Globe, 1990.

*Commercial Nuclear Power Plants*

As a result of the ban on nuclear fuel reprocessing in 1977, large amounts of spent nuclear fuel wastes have accumulated at commercial nuclear power plants. Currently, these wastes are being stored at each individual reactor site and, eventually, they will have to be retrieved, treated, and stored in the planned deep geological repository site. In addition, others such as transuranic and mixed wastes are currently being generated at these facilities as a result of ongoing activities (Lin, 1991, pp. 377-385). Commercial nuclear plants that produce radioactive hazardous waste are also widely distributed across the United States, with slightly fewer sites in the West than in other regions.

**Table 3**

**Commercial Nuclear Power Production, by U.S. Region**

| Region | Average Level of Production | States with Higher than Average Regional Production | States with Lower than Average Regional Production |
|---|---|---|---|
| East | Moderate to Heavy | Pennsylvania | New Hampshire<br>Massachusetts<br>Rhode Island |
| South | Moderate | South Carolina | Oklahoma<br>Kentucky<br>Texas<br>Tennessee<br>West Virginia |
| North | Moderate | Illinois | Indiana<br>Iowa<br>North Dakota<br>South Dakota |
| West | Light to None | California<br>Arizona | |

Source: PC Globe, 1990.

***Federal Radioactive, Mixed, and Hazardous Waste Sites***

As previously indicated, according to the Congressional Budget Office (CBO), the federal government is responsible and liable for the handling of hazardous wastes at more than nine thousand facilities. The majority of these facilities have no detectable levels of uncontrolled contamination; less than one thousand need to be further investigated for potentially hazardous contamination. However, 116 of these facilities were considered dangerous enough to be listed on the NPL as of July of 1991 (U.S. EPA, 1991b, p. 3). Nearly one-half of these federal NPL sites are located in the Western region, with the largest concentrations in California and Washington.

**Table 4**

**Federal Uncontrolled Hazardous Waste Sites, by U.S. Region**

| Region | Number of Sites | States with a Notably High Number of Sites* | States with a Notably Low Number of Sites** |
|---|---|---|---|
| East | 23 | New Jersey | Vermont |
| South | 21 | | Kentucky<br>Arkansas<br>Mississippi<br>West Virginia |
| North | 16 | | Indiana<br>Michigan<br>Wisconsin<br>North Dakota |
| West | 55 | California<br>Washington | Montana<br>Nevada |

* Those states with more than four sites.
** Those states with no sites.

Source: EPA, 1991b.

*Department of Defense Uncontrolled Hazardous Waste Sites*

The DoD is responsible for a vast majority of the total number of federal waste sites included on the NPL, nearly ninety percent of the total (U.S. CBO, 1990, p. 17). The wastes accumulated at these sites come from the production of highly hazardous weaponry and the maintenance and repair of military hardware. A large portion of these waste sites are located in military bases in the West.

**Table 5**

**Department of Defense Uncontrolled Hazardous Waste Sites, by U.S. Region**

| Region | Number of Sites | States with a Notably High Number of Sites* | States with a Notably Low Number of Sites** |
|---|---|---|---|
| East | 20 | Pennsylvania<br>New Jersey | Vermont |
| South | 17 | Florida | Kentucky<br>Arkansas<br>Mississippi<br>West Virginia<br>South Carolina |
| North | 12 | | Indiana<br>Michigan<br>Wisconsin<br>North Dakota |
| West | 42 | California<br>Washington | New Mexico<br>Montana<br>Nevada |

* Those states with more than three sites.
** Those states with no sites.

Source: EPA, 1991b.

### *Total Uncontrolled Hazardous Waste Sites*

The EPA estimates and regularly updates the total number of uncontrolled hazardous waste sites in the United States. As of July 1991, 1,211 total sites were listed on the NPL. Interestingly, the North and East still contain substantially more wastes sites than do the South and West (U.S. EPA, 1991b, p. 3) even though the nation's industrial base has been shifting South and West over the past two decades. This concentration of hazardous wastes in the North and East is one of the longer term consequences of earlier decades when the North and East were home to the largest number of manufacturing firms.

**Table 6**

**Total Uncontrolled Hazardous Waste Sites, by U.S. Region**

| Region | Number of Sites | States with a Notably High Number of Sites* | States with a Notably Low Number of Sites** |
|---|---|---|---|
| East | 376 | Pennsylvania<br>New York<br>New Jersey | Maine<br>Vermont |
| South | 272 | Florida | West Virginia |
| North | 328 | Michigan | North Dakota<br>South Dakota<br>Nebraska |
| West | 225 | California<br>Washington | Hawaii<br>Alaska<br>Idaho<br>Montana<br>Nevada<br>Oregon |

* Those states with more than fifty sites.
** Those states with less than ten sites.

Source: EPA, 1991b.

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# HAZARDOUS WASTE POLICY, LEGAL ISSUES, AND THEIR EMPLOYMENT CONSEQUENCES

## Introduction

Public policy and legal considerations must inevitably affect the supply of and demand for both personnel in environmental occupations and the specific types of environmental workers required to perform various jobs. This section examines several important dimensions of hazardous materials policy, legislation, and regulation—ones that are likely to have significant effects on future supply and demand and on related human resource issues. These include

- public perceptions of hazardous materials and, especially, hazardous waste;
- the continuing need for public laws to maintain the environment;
- the impact of major laws regulating institutions that produce hazardous waste;
- factors that inhibit effective policy implementation;
- American policy on exporting hazardous waste to less developed countries; and
- other major policy and legal issues that affect most types of polluters or individual classes of polluters.

Addressing these issues requires at least brief coverage of many different topics, including insurance and bankruptcy law, international treaties, and forms of interaction between government and industry and between federal and state governments. Our discussion here concentrates on the importance of these subjects for future cleanup of Superfund sites, importance that results from the potentially enormous impact of this work on environmental human resource requirements. (The federal Superfund program is described later in this section.) However, these issues also have important implications for the future human resource needs of private industry and government entities, especially since all employers will be competing for the same pool of trained environmental workers.

Some of these issues are fairly well known, especially where the popular press has examined them at length. However, other relevant arguments have been discussed only in trade journals and courtrooms, away from public scrutiny. In order to provide a broad perspective on important legal and policy issues, some of these less accessible topics will be explicitly addressed in this report. Although it is not our intention to cover all of the issues that policymakers and enforcers must consider, by presenting a range of topics and stressing the current difficulties encountered by the legal system in resolving lawsuits, we demonstrate the complex parameters that influence the supply of and demand for hazardous materials technicians and other environmental workers in the United States.

## Public Perceptions of Hazardous Waste

Several recent reports (Dwyer, 1990; Kunreuther, 1991; U.S. EPA, 1990) suggest that the United States has developed an environmental regulatory process in which the Environmental Protection Agency (EPA) responds to laws passed by Congress, which, in turn, are shaped by the public's conception of environmental issues and legislators' related political aims. In broad terms, the public largely determines how much pollution is unacceptable; and, in fact, until relatively recently, their tolerance for pollution was fairly high, especially when environmental degradation was viewed as someone else's problem. Now, the public has little tolerance for environmental pollution. Reflecting on this situation, at least one observer has noted that as a result of the public's current views, the environmental movement has broadened its agenda from demanding "not in my backyard" (NIMBY) to "not in *anybody's* backyard" (Heiman, 1990).

This shifting public perception has several implications for hazardous waste policy and resulting work-force requirements. Most importantly, it suggests that the public, as they drive up our nation's waste treatment and disposal costs, may have recognized that source reduction is the most powerful way to limit environmental damage. As a result, source reduction activities such as the development of less hazardous alternative products and production methods may create some of the largest future growth in work-force demand. In addition, source reduction efforts generally involve the "clean" side of environmental management in contrast to the dirtier jobs required for environmental cleanup. Consequently, a shift toward source reduction is likely to increase the amount of interest in environmental careers even beyond their currently high levels.

The U.S. EPA (1989) is aware that more responsive public, state, and local agencies and industry have already achieved some success in reducing hazardous materials production, treatment, and disposal. However, source reduction has not eliminated the need for hazardous waste disposal facilities. As additional sites are being selected, new groups are assuming influential decision-making roles. In particular, minority communities are advancing their own views of how to solve the hazardous waste problem. In many cases, these racial-ethnic groups are countering the prevailing view that it is acceptable for communities and industries to locate potentially hazardous facilities in poor neighborhoods inhabited predominantly by African Americans, Hispanics, and Native Americans (Kay, 1991; Moore, 1991; Morgan, 1991).

The growth of newly established coalitions among racial, ethnic, and even industrial groups indicates that the public will continue to be interested in affecting environmental policy. It also suggests that these coalitions may pursue agendas that could affect the supply of available personnel to fill various types of environmental jobs. Specifically, minority communities may place substantial pressure on training and educational programs for environmental workers. For instance, they may try to ensure that members of racial and ethnic minority groups are not trained solely for the "dirtier environmental jobs" that require only limited technical education and training.

Public interest in environmental policy has a variety of positive and negative implications. The U.S. EPA (1990) has recommended that society set "environmental priorities based on risk," a relatively new concept in environmental planning. However, achieving this goal will not be easy because according to the U.S. EPA (1987, 1990), experts and the public perceive risk differently. To some extent, this difference is a good one: the public has particular views that must be accommodated by politicians and technocrats. However, in other respects this perceptual difference is a bad one: it reflects the fact that the government and technocrats communicate poorly with the public and differ in their views of how to achieve the greatest good for the greatest numbers of people (Hadden, 1991). The public clearly demands some control over hazardous waste policy yet in doing so advances an agenda that may inhibit a more effective and cohesive approach.

Hazardous waste dumps, the targets of the Superfund program, are important sources of pollution because of both their real and publicly perceived health risks. The public clearly views dumps as the most significant environmental threat, and Congress has responded to this popular opinion by elevating Superfund cleanups and waste tracking to the top of the EPA's agenda. If the EPA decided to pursue a more effective policy that would rank hazards based on both publicly perceived and scientifically measured risks, it would have to re-educate the public and important members of Congress on the theory of risk management—a formidable task, indeed.

For example, the EPA states that it "should attach as much importance to reducing ecological risk as it does to reducing human health risk." If the EPA were to follow this strategy, it might concentrate more of its resources on reducing wildlife habitat alteration and destruction, stratospheric ozone depletion, and global climate change (U.S. EPA, 1990). If it were to revise its strategy for dealing with acute human health risks—of which the public sees hazardous waste dumps as the most pressing (U.S. EPA, 1987)—the EPA, along with the Occupational Safety and Health Administration (OSHA), might concentrate on workers' exposure to chemicals in the workplace or on indoor pollution from radon, consumer products, and tobacco smoke.

These shifts in emphasis on human resources might alter both aggregate demand for environmental personnel and the types of individuals required to meet a revised environmental agenda. For example, if the EPA were free to promulgate environmental policy based on risk management, the Department of Defense (DoD), the Department of Energy (DOE), the hazardous materials industry, and the EPA itself might actually require a smaller hazmat work force as the nation redirected it resources to reduce only its more risky hazards. However, activities such as public health education, restoration of wildlife habitats, or research on stratospheric ozone and climactic change would demand a larger professional and scientific work force rather than greater numbers of hazmat personnel, especially at the technician level.

## The Continuing Need for Public Laws to Maintain the Environment

Economists analyze pollution by looking at its costs and benefits. Consider, for example, noise pollution. A homeowner plays his stereo so loud that neighbors regularly complain. The noisemaker incurs only the small monetary cost of running his stereo and, perhaps, the time cost of answering neighbors' threatening phone calls. He enjoys a great net benefit from listening to his music. This is not the case for his neighbors, who not only endure an emotional toll from having to hear his music but also must absorb a net cost from hearing it. Even assuming the stereo owner produces this cost inadvertently, it is still real to his neighbors.

An economist would argue that the noisemaker's stereo playing produces *negative externalities* (i.e., costs that are absorbed by people other than the producer). Therefore, the total cost of excessively loud music, which is the social cost, is equal to the internal and external costs of playing the music (i.e., the cost to the stereo owner plus the emotional cost to the neighbors).

Similarly, the social costs of pollution are, by definition, higher than the internal costs borne by the polluter. Because polluters would elect to pay only their internal costs of pollution, they pollute much more than they would if they had to pay the social costs. The polluter, as profit maximizer, produces an individually optimal amount of pollution, which is greater than the socially optimal amount.

Environmental laws are therefore necessary to align polluters' individual priorities with those of society by charging them their effluents' societal costs. Some proposed regulations call for an effluent tax that would tax pollutants at a rate approximating the social cost of the pollution. If one cubic foot of garbage costs society two dollars in cleanup and monitoring costs, the effluent tax would be assessed at two dollars per cubic foot of garbage. Such a method is nevertheless limited by the sophistication of environmental economic analysis, which is also used to assess damages in lawsuits. (See Keeva, 1991, for the likely effect of the *Exxon Valdez* lawsuit on developing methods for estimating natural resource damages.)

Both economic theory and practical experience teach that few people will clean up wastes if they are not forced to do so. As a result, all other things being equal, Congress will continue to pass laws that will increase the environmental work force by increasing waste management and cleanup requirements. However, it has been noted that individuals adjust their production and consumption of hazardous materials according to the cost of their actions. Such costs may include effluent fees; updated equipment, disposal, or export fees; personnel training costs; and even reduced production or demand for output (resulting from negative publicity). With ever-rising costs, basic economics implies that in the long run individuals will produce and consume less and fewer hazardous materials and society will require fewer workers to manage these materials.

This, however, is not the only possible scenario. Americans could maintain their domestic production and consumption of hazardous materials in the face of a price increase if (1) they were indifferent to the price or (2) they cut their costs commensurately by operating illegally, for example, or developing more efficient equipment. If less hazardous materials were used, fewer environmental workers would be necessary. However, in the short run, companies may not be able to reduce their usage and production of hazardous materials, particularly until viable materials and production processes are developed. Therefore, standards that lower the maximum allowable dosages of hazardous materials would likely increase the number of environmental workers that are necessary in the short term to achieve those lower levels.

From the preceding discussion, one can infer that as larger numbers of substances are listed as hazardous, more environmental workers will be necessary to ensure that those substances are handled properly. The part of the environmental work force that is made up of technicians and technically trained operatives is likely to be heavily affected by this growing list of regulated substances because these individuals have primary responsibility for strictly regulated handling, monitoring, and cleanup of hazardous materials. In addition, new legal theories created in legislatures and courtrooms will continue to increase the knowledge needed to develop hazardous materials policy and to assess legal remedies. At the very least, government and industry will doubtless need to employ more technicians in the field and in laboratories to respond to the growing volume of environmental litigation and regulation.

## The Impact of Major Laws Regulating Institutions That Produce Hazardous Waste

Legislation and regulations controlling hazardous materials and waste touch every industry and area of the environment. The following is a summary of relevant environmental legislation, taken largely from the U.S. Congressional Budget Office (CBO) (1990, p. 11). It is included in this section to illustrate the wide arena of human activity that is now affected by laws regulating hazardous waste production.

- *The Federal Water Pollution Control Act of 1952 and the Air Pollution Control Act of 1955* were the first two major statutes regulating emissions of hazardous substances in the air and water—the most likely channels for human exposure to hazardous waste. Congress significantly strengthened these laws in the *Clean Air Amendments of 1970* (known as the Clean Air Act) and the *Federal Water Pollution Control Act Amendments of 1972* (known as the Clean Water Act).

- *The Atomic Energy Act of 1954* still regulates the handling and storage of radioactive wastes, which are generated primarily at nuclear power reactors and at federal nuclear weapons plants. Although radioactive wastes are specifically excluded under the Resource Conservation and Recovery Act of 1976 (RCRA), hazardous waste sites contaminated with radioactive waste are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). (These acts are described below.)

- *The Federal Environmental Pesticide Control Act of 1972* regulated the manufacture and use of pesticides and pesticide products to ensure safety according to directions on their labels. This act was amended by *The Insecticide, Fungicide, and Rodenticide Act of 1975.*

- *The Safe Drinking Water Act of 1974* aimed at protecting the public from various contaminants in the drinking water supply.

- *The Toxic Substances Control Act of 1976* gave the EPA broader regulatory authority to identify and control chemical products that may threaten human health through their manufacture, commercial distribution, or disposal.

- *The Resource Conservation and Recovery Act of 1976 (RCRA)* provided for the overall management of hazardous wastes. This act established appropriate techniques and regulations for handling all hazardous waste from "cradle to grave" (i.e., from generation to disposal).

- *The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* addressed a problem relatively ignored by the RCRA—namely, what to do about hazardous waste contamination from past disposal activities. The CERCLA established a federal program, commonly known as Superfund, that would finance the cleanup of the nation's most contaminated waste sites. Superfund set detailed guidelines for cleaning up these sites and established a system of legal liability in which those responsible for the wastes would be forced to pay for their cleanup.

- *The Hazardous and Solid Waste Amendments of 1984 (HSWA)* significantly strengthened the RCRA, primarily in response to the EPA's slow progress in implementing it. These amendments also required the cleanup of contamination from leaking underground storage tanks, which the CERCLA did not regulate.

- *The Superfund Amendments and Reauthorization Act of 1986 (SARA)* strengthened the CERCLA and significantly increased its fund from $1.6 billion to $8.5 billion to clean up the nation's most contaminated hazardous waste sites. ARA provided the EPA with greater permanent solutions rather than merely removal and relocation. This legislation also mandated federal agencies to identify, investigate, and clean up any hazardous waste sites at their facilities.

- *The Clean Air Amendments of 1990* (known as the Clean Air Act of 1990) have substantially changed federal regulation of ambient discharges. This most recent set of amendments has increased the EPA's mandate to enforce much stricter control over a variety of air pollutants. Included among these new regulations is a goal to reduce acid rain by ten million tons by the year 2000. Also, a goal has been set to cut ninety percent of industry emissions of 189 industrial, cancer-causing substances over the next ten years. Perhaps most significantly, the 1990 Clean Air Act has instituted a flexible policy on industrial polluters that permits them to trade allowances of substance emissions as though they were economic commodities.

This lengthy list demonstrates that even without passage of additional legislation, there are many opportunities for employment of hazardous materials technicians and related workers responsible for monitoring water, soil, and air pollution; tracking, monitoring, and handling industrial hazardous materials and waste; and working in waste cleanup and environmental remediation activities. In addition, newly passed and planned future legislation will likely expand these employment opportunities. Throughout the rest of this section, possible legislative additions will be discussed.

### Resolving Challenges to Effective Policy Implementation

The EPA continues to face pressure to reduce the hazards from Superfund sites as quickly as possible. To achieve this goal, the agency is modifying the Hazard Ranking System (HRS), which is used to determine whether a site should be placed on the National Priorities List (NPL). Such changes may have important implications for the kinds of skills that technician-level environmental personnel must possess. Specifically, by changing the HRS and accelerating site evaluation, the EPA will likely begin to remediate NPL sites that are qualitatively different from sites currently at the top of the list. As a result, there will probably be more future opportunities for EPA contractors working on the "front end" of cleanup activities, where environmental personnel—including technicians—will be responsible for preliminary site assessments and investigations. In addition, these future NPL cleanups may require that technicians emphasize other skills that are different from those needed by today's technicians if the types of contamination differ from those currently on the NPL.

The future need for environmental personnel will also be shaped by the cleanup strategies that the EPA is implementing today. According to one perspective, at the present time the EPA does not appear to be carrying out the investigatory research necessary to remediate waste sites permanently. Specifically, if the EPA is receiving inadequate health assessments of waste sites from the Agency for Toxic Substances and Disease Registry (ATSDR), future cleanup efforts may be required as new and better data emerge on health consequences (Associated Press, 1991). Furthermore, the EPA has experienced difficulty reaching its Records of Decision (RODs), which state "what remedy the government has chosen [for a Superfund site] and the reasons for doing so" (U.S. Congress, OTA, 1988b). The impermanence of many current solutions implies that the EPA may have to revisit sites in the future. Subsequent work would create a continuing demand for technicians and other environmental personnel.

### U.S. Policy on Exporting Hazardous Waste to Less Developed Countries

The environmental laws of less developed nations are less stringent and their enforcement efforts are less effective than those of industrialized nations. These differences have had two significant consequences (LaDou, 1991). First, some nations accept waste exports as a means of boosting their poor economies. This arrangement works well for polluters in industrial nations facing high disposal costs. In the United States, HSWA of 1984 requires that domestic waste exporters secure the consent of waste-importing countries prior to shipping hazardous wastes, although it does not require that their treatment facilities meet any safety standards (Williams, 1991). Low standards have important economic implications. For example, disposal costs in less developed countries (LDCs) are six times lower than those in industrialized nations, and these savings have prompted "at least 11 developing countries [to become the repositories of] waste from the U.S. and Europe since 1986, while an additional 38 were approached" (Lief, Barnes, & Zulueta, 1988, pp. 54-56).

Second, the low labor costs and relatively unrestricted regulatory climate of LDCs attract the production facilities of multinational corporations. While that investment clearly enriches LDCs, the unsafe factories and newly overpopulated cities deplete their natural resources. However, given the monetary benefits of industrial investment, host governments are understandably reluctant to strengthen their environmental regulations.

Mexico is a good example of an LDC with significant economic incentive for accepting environmentally harmful investment by multinational corporations. The United States has significant and profitable capital invested in Mexico (Perry, Sanchez, Glaze, & Mazari, 1990). The *maquiladoras*, the term for foreign-owned industrial plants in Mexico, have grown immensely in the past twenty-five years from twelve plants in 1965 to 1,490 plants in 1988, with a proportional rise in employment. These plants range from those that manufacture leather and furniture to those that produce electrical and electronic parts and equipment. All of these industries use a wide variety of hazardous materials and create substantial hazardous waste.

However, attitudes on the part of both highly industrialized and less developed nations may be changing with potentially important implications especially for the United States. The industrialized countries have started to take interest in the developing countries' environmental damage. In fact, most developed nations now allocate a small proportion of their budgets to address home companies' practices in LDCs, and international environmental organizations (e.g., the World Health Organization and the International Labour Office) and international lenders are assisting third world nations in assessing their hazards and developing standards and guidelines. International lenders sometimes require LDCs to safeguard their environment in order to receive investment capital.

Mexico, unlike other LDCs, has banned the importation of hazardous waste for final disposal unless intended for recycling or reuse. Furthermore, while most LDCs must bear the environmental costs of foreign investment alone, because of the *maquiladoras'* proximity to the U.S. border, the United States feels the effects of pollution from multinational corporations, as well. This distance may be too close for comfort: San Diego's beaches are so polluted with waste from the Tijuana River that the city, state, and federal governments are providing most of the $192 million necessary to build a treatment plant on the border. Other third world countries are not as "lucky" to have their pollution so readily felt by nations that can pay for abatement.

Of course, not all countries are as fortunate as the United States with respect to the priorities they can place on environmental management. Nations that can barely feed and clothe their populations often need foreign currency, whatever its source.

The export and import of hazardous waste has created difficulties among countries attempting to maintain friendly foreign relations (Williams, 1991). Consequently, the United States is paying greater attention to its international environmental policy. As of August 1992, the Basel Convention, the major convention governing hazardous waste exports, had not yet been ratified by enough countries to become law, although some countries may follow the convention regardless of its legal status. Some members of Congress have introduced the Waste Export Control Act (WECA) to implement most of the policies set forth at the Basel Convention (Mounteer, 1991), while others call for a ban on U.S. waste exports and imports (Williams & Cannon, 1991, p. 10,487).

Any future acts are unlikely to widen the possibility of exporting waste to other countries. The future tightening of export controls could have a significant impact on human resource requirements in environmental fields. Although only one percent of America's hazardous waste is exported legally, it is unclear how much waste is exported illegally (Mounteer, 1991). All other things being equal, a contraction of legal exports or a reduction of illegal exports would increase the amount of waste to be treated domestically. It would also create additional incentives for waste minimization in the form of recycling and alternative materials and production processes. As more waste is treated domestically, more technicians will be needed. However, in the longer run, waste minimizations will likely reduce demand for technician-level personnel.

## Issues Common to All or Most Types of Polluters

### Legal Issues

#### ***Litigation's Impact on the Volume of Remedial Work in the United States***

The current legal situation surrounding environmental cleanup efforts may be one of the most important factors affecting human resource needs. This situation stems, in part, from the broader legal climate in the United States: "Because of the generally cooperative spirit between government and industry in Europe and Japan, litigation is much less common than in the United States" (Beecher & Rappaport, 1990). Drawing from a number of studies comparing U.S. health, labor, and racial policies to their European and Japanese counterparts, Robert Kagan (1991) concludes that American policy is distinguished by the following:

- more complex legal rules
- more formal, adversarial procedures for resolving political and scientific disputes
- slower, more costly forms of legal contestation
- stronger, more punitive legal sanctions
- more frequent judicial review of and intervention into administrative decisions
- more political controversy about (and more frequent change of) legal rules and institutions

In his recent case study of environmental regulation of the Port of Oakland's dredging activities, Kagan (1991) dubs the American policy-making system, and environmental policy in particular, ***adversarial legalism.*** He states that adversarial legalism is marked by high levels of "formal legal contestation," "litigant activism," and "substantive legal uncertainty" and that U.S. environmental policy demonstrates these same characteristics. Rather than being a natural manifestation of the aggressive American character, Kagan asserts that adversarial legalism stems from efforts by decentralized, nonactivist political structures to achieve activist government policies.

Given Americans' distrust of centralized authority, it is likely that the multitude of involved parties (the EPA, Department of Transportation, the Army Corps of Engineers, the U.S. Fish and Wildlife Service, local and regional water quality agencies, state and municipal governments, business associations, and public interest groups, to name a few) will continue to use the courts to solve their problems (Hadden, 1991). However, such a strategy addresses important policy questions individually and haphazardly rather than methodically from the start, as could an agency with broad powers to balance the conflicting concerns of various groups. Until the public regains faith in government to play that role of final arbiter and the government assumes that role, an adversarial legal environment policy will remain (pp. 398-399).

How does the adversarial legal process affect the labor market for hazardous materials technicians? The effects are complex. First, it discourages new projects that involve hazardous materials (discussed in the section on liability and insurance that follows). Fewer projects mean that fewer technicians and other personnel are necessary. Second, the adversarial legal process discourages current projects, which may be postponed or scrapped altogether because of legal costs (such as the Port of Oakland dredging case). Again, fewer projects lead to less market demand for technicians. Finally, on the other hand, legal uncertainty and adversarialism may actually *increase* the volume of necessary environmental work by increasing the amount of information, remediation, and source minimization required by the diverse contestants. Diamond of the U.S. EPA (1991a), for instance, maintains that the agency's recent "enforcement first/squeeze-as-hard-as-you-can" policy is achieving significant results. This implies, at least, that there will be a growing need for remediation technicians.

What is the bottom line impact of these conflicting influences on work-force requirements, either now or in the future? Unfortunately, we will not know until the United States promulgates a stronger central environmental policy. From a human resource planning perspective—with its attendant need for employment statistics—this is particularly true because decentralized control of the process means that no one agency has responsibility for employing, regulating, or keeping track of hazardous materials technicians (beyond OSHA's certification program). This situation guarantees that it will be difficult to gather comprehensive statistics about the hazardous materials work force.

### *An Alternative to Litigation*

As an alternative to current expensive protracted adversarial relationships, some companies and governments are testing the methods of alternative dispute resolution (ADR) or environmental dispute resolution (EDR) with varying degrees of success. Both ADR and EDR are "more cooperative system[s] emphasizing participants' common goals," which include mediation and a host of other techniques emphasizing mutual negotiations (Nakamura, Church, & Cooper, 1991). Both industry and government may cut litigation costs by employing EDR to assess liability.

For example, Clean Sites, Inc. is a private company established in the early 1980s to accelerate site cleanups (Hanson, 1987, p. 14). Along with evaluating sites and managing cleanups, the company has been successful at mediating settlements between potentially responsible parties (PRPs) (p. 15). Clean Sites, Inc. brings PRPs together by explaining the complex issues to companies who do not understand their obligations. Not all experiences with EDR have been successful, however. New York State, for example, initiated an experiment with EDR that was doomed to fail as a result of the state's lack of commitment (Nakamura et al., 1991).

While their progenitors hail ADR and EDR as panaceas, New York's experience demonstrates that EDR will work best when the government facilitates bringing all PRPs to the table (through legal orders and personnel) and provides incentives for the participants to reach a conclusion. Furthermore, EDR will not work when PRPs have disputes that must be settled in court. If PRPs were able to use EDR to help in cleaning up waste sites, more technicians would be necessary in the short run and fewer in the long run. However, the literature demonstrates that EDR cannot speed up all negotiations.

While location is the central issue in facilitating decisions where all sides claim "not in my backyard," liability is the key issue in cleanup proceedings where all sides claim "not in my back pocket." The two questions a court must answer when assigning liability are (1) who contributed to the harm and (2) who will pay for the harm and how much? Because the answers to those questions partially determine environmental policy and are, in turn, partially determined by environmental policy, liability is a central issue. The questions are interrelated, and the answers affect and are affected by the incentives for different parties to follow the rules or even to participate at all.

## Liability for Environmental Contamination

### *Who Participates*

"[F]our classes of persons may be liable for costs incurred in response to the release and cleanup of hazardous substances ('response costs') and damages to natural resources": current facility owners, past owners at time of disposal, "generators" (those who arrange for disposal or transport for disposal or treatment), and "transporters" (Steinbeck, 1989, p. 57). SARA (Superfund Amendments and Reauthorization Act of 1986) specifies that "facilities owned or operated by a department, agency, or instrumentality of the United States" are subject to CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980) (Steinbeck, 1989, pp. 55-56). In other words, the government is at least nominally accountable to the same laws as industry. (However, the section on federal government liability that follows provides a different view.)

### *Who Pays?*

In contrast to more lenient European and Japanese policies, being a good PRP according to the laws and scientific thought of the time does not excuse a PRP from liability for damages (Beecher & Rappaport, 1990, p. 31). Section 101(32) of CERCLA imposes strict liability on responsible parties, which means that "defendants [who] exercised due care or were not negligent cannot . . . avoid liability under the Act" (Steinbeck, 1989, p. 61). In the United States, customers who legitimately dump their hazardous wastes at a licensed dump can still be liable for cleanup costs. Bruce Becker, an attorney who represented a small septic-tank cleanout company that occasionally transported hazardous waste to the top Superfund site in New York state, states,

> [CERCLA]'s a stiff law. I can understand that there is a social purpose behind it, but there's also a social purpose behind licensing these sites to handle material properly. If the state licensed the place, why isn't the state liable? (quoted in Finegan, 1988, p. 56)

Courts will try to apportion costs fairly based on the estimated contributions to harm if the harm is divisible. Superfund sites contain wastes from a number of sources, which makes the job of assigning liability to individual sources difficult. If the harm is indivisible, courts may even apportion damages based on a number of factors. To address the cases in which liability is truly indivisible or in which few PRPs can be found, however, the courts have also imposed the standard of joint and several liability on responsible parties. This standard holds that "[if] the harm is indivisible, or there is no reasonable basis for division, each party is subject to liability for the entire harm" (Steinbeck, 1989, p. 62). However, the joint and several liability standard can be used to penalize the defendant with the most substantial resources, regardless of their contribution to the harm.

The EPA, under pressure from Congress, wants PRPs rather than the government to pay for cleanups. In an era of high budget deficits, the government's concern is valid. Nevertheless, even an honest PRP faced with a hazmat lawsuit would avoid taking responsibility for a fair share of the costs because any liability admitted could be magnified disproportionately. As suggested above, using adversarial tactics is almost the only available strategy for a small company being sued for damages that are much higher than the company's true share of the harm.

### ***What If the Courts or Congress Adopt a Different Standard of Liability?***

The answer to this question is unclear. The strict as well as the joint and several standards of liability were applied to increase the incentives for entities to minimize their potential hazards. In addition, they were intended to increase the number of legally defined culprits who can pay for remediation. It is difficult to determine whether these standards decrease the use of hazardous materials through their long-term deterrent effects, whether they increase the numbers of cleanups by giving the courts a way to find a responsible party for most situations, or whether they decrease the number of cleanups through their adversarial effects.

To the extent that current standards of liability increase insurance companies' reluctance to write environmental insurance policies, it is also unclear how increased availability of insurance would affect the number of cleanups. As suggested below, an increase in the availability of insurance would mean that companies might be regulated more effectively, which would imply that fewer technicians would be necessary for cleanups in the long run. On the other hand, the availability of insurance might either increase or decrease the number of firms handling hazardous materials. Furthermore, those companies who are insured clean up their facilities more rapidly than do uninsured companies and might be more likely to handle their materials more carefully. Although it is known that more cleanups require more technicians, making further predictions is mere speculation.

## Insurance

### *Coverage*

The insurance arena exhibits the "substantive legal uncertainty" inherent in the adversarial legalistic battle of "not in my back pocket." Insurance policies are often written using vague language that requires courts to determine the limits of coverage. Although the "established principles of contract interpretation" (Miller, 1991, p. 75) resolve ambiguous policy language in the insured's favor, courts may nonetheless differ over what language is ambiguous. Such conclusions do affect how soon and how much waste is cleaned up since insured polluters clean up facilities more readily than do uninsured polluters (Miller, 1991, pp. 73-74). Currently, two representative ambiguities are being cleared up by the courts: (1) definitions of damages or property damages and (2) "sudden and accidental," a qualifying statement found in some insurance policies.

### *Availability of Insurance*

> Within a month, I knew we would not be able to get insurance for what we did. . . . It really hit us. Between early spring [1984] when we had taken a look and decided insurance would be expensive but available and when we looked in the summer, no one would touch us. (Charles W. Powers, founding president of Clean Sites, Inc., quoted in Hanson, 1987)

HSWA requires hazardous material transfer, storage, or disposal facilities (TSDFs) to meet financial obligations to cover their liability in case of accidents through either third-party insurance or self-insurance. However, because insurance companies have found current standards of liability too risky or uncertain (see preceding section), they either refuse to offer policies, charge incredible premiums for inclusive policies, or restrict policy coverage to narrow claims (Black, 1990). The majority of TSDFs cannot find reasonably priced environmental liability insurance. Thus, the experience of Clean Sites, Inc. is by no means isolated.

TSDFs that do business with or for government agencies may be indemnified by the government for their work. For example, in March 1985, the EPA agreed to indemnify Clean Sites for their work, an agreement that later had to be renegotiated once SARA was passed in 1986 (Hanson, 1987). Steinbeck (1989) suggests that the DoD indemnify contractors who cannot find reasonably priced environmental liability insurance.

However, other companies are not lucky enough to have the United States assume their environmental liability. As a result, a large percentage of firms simply do not comply with the financial requirements and hope not to be caught (Black, 1990). The majority of TSDFs rely on self-insurance and the strength of their balance sheet to guarantee their ability to cover their potential liability. In theory, one could devise a financial self-insurance requirement that would generate the same monetary advantages as third-party insurance. However, Black demonstrates that this is not the current practice: despite requirements that seemingly address future claims, self-insured firms cannot guarantee the ability to pay future potential liabilities because they are not required to accumulate sufficient funds to pay future claims.

Nor does self-insurance guarantee the same public policy advantages as third-party insurance. Self-insurers fail to regulate themselves the way insurance companies would. There is some evidence that Congress intended the insurance industry to act as a surrogate regulatory body as a result of their financial interest in keeping their premiums. When companies insure themselves, this regulatory function is lost. More stringent financial and insurance requirements would have a number of effects. First, fewer firms would be allowed to operate, which would decrease the number of technicians employed. Second, surviving firms would either violate the regulations or (it is hoped) add more personnel to comply with more stringent standards.

Whether these decreases and increases balance each other would depend on how much the demand for products varied with cost. The less people care about cost when purchasing products connected with hazardous materials, the less would an increase in cost decrease product demand. More stringent standards might tighten the hazardous materials technician market in the short run but would benefit society in the long run by decreasing the amount of waste produced, handled, or disposed as well as the numbers of people necessary to handle the waste.

## What Issues are Specific to Various Polluters?

### Federal Government Liability

The federal government may not be held to the same standard of liability as other TSDFs. First, the Reagan and Bush administrations have stated that the Department of Justice cannot sue federal agencies such as the Department of Defense (DoD) and the Department of Energy (DOE) because of separation of powers' conflicts, although some observers disagree with this assessment (Smith, 1991; Steinberg, 1990; Turque & McCormick, 1990). Second, federal employees have significant protection against state criminal prosecutions (Smith, 1991). Third, some observers have argued that federal facilities do not comply with regulations because of "a continuing perception of immunity [from environmental laws that were subsequently amended to include federal facilities], lack of leadership attention, and skewed budgetary priorities," which emphasized the agencies' achieving their "primary mission" with their funding rather than attending to environmental concerns.

However, DoD and DOE officials have recently affirmed that their agencies will be working with states and the EPA at the insistence of their secretaries (Milnes, 1991; Ziemer, 1991). While these agencies have only recently focused attention on environmental management, they appear to be moving ahead in earnest. Milnes of the DoD and Ziemer of the DOE recognize the need for more environmentally trained personnel to achieve their agency's environmental cleanup agendas, although it is too early to evaluate their success in these efforts. Nevertheless, it is clear that the DOE in particular is moving ahead aggressively to evaluate the magnitude of the human resource need and to identify the training and retraining strategies that must underlie development of the environmental work force.

## States

### *State Legislation*

Although the RCRA, CERCLA, and SARA have gained the most attention in discussions of environmental laws, individual states are allowed to set up their own programs to supplement or replace federal programs. These state programs must be as stringent as federal programs, so states need to spend much time convincing federal regulators to authorize their programs. California, for example, has spent five years comparing its Hazardous Waste Control Act (HWCA) with the RCRA in order to replace the 1976 act, even though the HWCA actually predates the RCRA (Gunther, 1990). New Jersey, Massachusetts, New Hampshire, Ohio, and Tennessee have also led the way by initiating aggressive state hazardous waste legislation (Wagner, 1989).

Grassroots movements oppose new waste facilities, hoping to drive up the costs of waste and thus counterbalance the incentives for disposing of, rather than recycling, waste (Gordon, 1986; Pytte, 1990). Some states are closing their remaining landfills to avoid problems, and some are restricting what can be disposed of in landfills to preserve remaining capacity. Using the terminology introduced at the beginning of this section, increasing the cost of disposing waste will force businesses to internalize more of the costs, which should decrease the amount that is disposed. Some evidence suggests that this is indeed happening. However, as long as polluters are free to ship their waste to states with excess disposal capacities, polluters may continue to pollute as usual.

States may not regulate interstate commerce; some states such as Indiana, Oregon, Ohio, and Pennsylvania, however, have tried or are trying to limit the amount of waste other states can export over their borders (Darcey, 1991a, 1991b). Members of Congress are introducing a number of bills to help clarify this situation under RCRA reauthorization. The need is acute because as Representative Ben Erdreich (Democrat from Alabama) says: "[I]t's impossible to do long-term planning if you have no control over what [waste] enters your state" (Pytte, 1990). This discussion indicates that the demand for hazardous materials technicians will differ across the states as some aim to restrict their waste burdens. However, some states will maintain a high demand for technicians to monitor industry or to remediate NPL sites.

### Small Quantity Generators (SQGs)

SQGs such as dry-cleaning stores or automotive repair shops pose special problems for officials concerned with enforcing hazardous materials regulations for several reasons:

1. The small profits of small business limit the amount of money that they are willing to spend to comply with regulations.

2. Since few small businesses know of the *Federal Register* and less than one-half belong to a national trade association, many are ignorant of the requirements to which they are subject.

3. Officials have little time or resources to inspect the thousands of registered small businesses let alone inspect unregistered small businesses that might really require registration (large businesses are more visible and concentrated).

4. Most small businesses are located in or near residential areas, which increases the likelihood of human harm.

The first three factors are likely contributors to the "rampant" noncompliance among small businesses with waste regulations. To inform SQGs of their responsibilities, the EPA's Small Business Ombudsman Office answers thousands of telephone hot-line and mail inquiries in addition to distributing informational brochures and speaking at trade events. Other options may help to lower the cost of compliance to both the regulated and the regulators (Brown, 1988; Schwartz et al., 1989).

If the EPA devises methods to ensure that small quantity generators dispose of their wastes legally, the demand for hazardous materials technicians would burgeon. Schwartz et al. (1989) point out that small quantity generators actually produce much more than the one percent of all hazardous waste that they have been reported to produce. Cost-effective solutions to SQGs' waste problems would probably increase the demand for technicians to help recycle and dispose of wastes that are now being dumped illegally or unnecessarily.

## Summary

Scientists, economists, society, and politicians may disagree over which environmental problems present the most imminent threat, but few people believe either that the danger will diminish without attention or that current efforts are enough to maintain an acceptable level of safety. In the short run, the United States will need to employ more hazardous material technicians to assess and remediate known and newly discovered waste sites, to meet tighter restrictions on waste output, to treat new kinds of waste, and to fulfill the environmental cleanup and restoration mandates established by governmental entities.

Yet the cost of tighter restrictions on more kinds of waste will produce three dynamics that run counter to increasing demand for technicians—mechanization, process redesign, and product substitution. Businesses generally like to replace humans with machines for routine work that needs to be accomplished with precision, especially where worker health is an issue. The research that will be described later in this report indicates that hazardous materials technicians who are involved in site remediation activities perform physically demanding tasks in which one mistake can turn a five-minute job into a week-long job and possibly injure the environment or other people. As a result, where feasible, industry will doubtless attempt to mechanize appropriate chores, resulting in a decreasing demand for technicians.

Industry will almost certainly attempt to reduce the amounts of hazardous materials they produce both as by-products and end-products. Their efforts are already achieving some success. In order to reduce their hazardous output, hazardous costs, and hazardous liability, industry will recycle materials that can be recycled, replace materials that can be replaced, and redesign the production processes that can be redesigned. Moreover, consumers will demand ecologically sound products even if they have to spend more money for safety. Such changes in the "what and how" of business will help to stem the demand for hazardous materials technicians over the long run, although these changes will take time.

Finally, scientific and economic methodology may progress to the point where policymakers can actually apportion resources to gain the greatest good for the greatest number of people. Their highest priority may be hazardous materials in hazardous waste sites, but it is also likely that indoor air pollution and atmospheric ozone depletion may prove to be just as troublesome. To the extent that environmental problems and their champions compete for funding and public attention, problems other than hazardous materials may usurp some of the material and human resources that would otherwise be spent on hazardous materials threats. However, it will take some time before scientific and economic methodologies, along with useful data sources, can be used to help establish relative priorities concerning the resources that will be applied to correcting environmental problems.

In summary, although it is impossible to provide exact numbers, anticipated trends in public policy, legislation, and regulation clearly suggest that the United States will have a growing demand for hazardous materials technicians over the next twenty to thirty years. If the nation is also successful in developing necessary new technologies, demand will be limited along the way by new solutions until the hazardous materials work force remains stable or diminishes.

## WORK FORCE AND SKILL REQUIREMENTS OF EHM TECHNICIANS: FINDINGS FROM AN EMPLOYER SURVEY

### Background

This section reports findings from interviews and surveys of employers of environmental technicians and related personnel. MPR staff conducted these two data gathering activities in order to generate information on current labor market conditions for EHM technicians and related workers and on the skills that employers require of these employees. To provide a context for understanding these findings, this section begins with a description of the industry settings in which EHM technicians and related employees work and the broad range of duties that they perform. This background information has been compiled from a review of previous studies and government publications as well as from our own interviews with EHM managers.

### Who Employs Environmental Personnel?

The environmental industry is a highly diverse category of employers. For example, one major segment—environmental services—includes companies that provide private firms and government entities with environmental waste management, hazardous waste removal, and environmental management services as well as related laboratory and environmental equipment services. A recent study conducted by the ***Environmental Business Journal*** (Ferrier, 1992, pp. 6-11) indicates that environmental services firms represent a $132 billion business in the United States, employing about 814,000 workers.

A second large segment of the environmental industry includes private companies and public entities that generate environmental hazards and waste. Businesses and agencies in this sector are rarely classified as environmental entities. Instead, they may include manufacturers, agricultural processors, mining operations, public utilities, and national energy laboratories. These hazardous waste generating organizations employ about as many individuals in environmental jobs as do environmental services firms. In combination, these two largest sectors of the environmental industry include nearly two million American workers, about 1.5% of the employed civilian labor force (Ferrier, 1992, p. 6; Kutscher, 1991, p. 7).

Employment in environmental services is expected to grow substantially in the near future, although various parts of the industry will likely expand at different rates. *The Environmental Business Journal* recently provided data on the distribution of workers in various types of environmental service work and provided projections of employee growth by 1995.[2] These estimates are shown in Table 7.

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[2] It is much more difficult to estimate the distribution across industries of environmental employees working for hazardous waste generators because many of these individuals work in small companies where they have multiple job functions. In addition, even in larger corporations, many individuals with environmental responsibilities still have such job titles as safety specialist or even facilities technician or manager.

## Table 7
## Employment in the Environmental Services Industry, by Sector

| | 1992 Employment | Projected New Employment by 1995 | Percentage Increase by 1995 |
|---|---|---|---|
| Solid Waste | 185,000 | 64,000 | 35 |
| Resource Recovery and Recycling | 95,000 | 83,000 | 87 |
| Water Treatment Equipment | 88,000 | 40,000 | 45 |
| Hazardous Waste Management | 93,000 | 75,000 | 81 |
| Engineering and Consulting | 120,000 | 118,000 | 98 |
| Private Water Utilities | 55,000 | 15,000 | 27 |
| Pollution/Waste Management Equipment | 62,000 | 30,000 | 48 |
| Air Pollution Control | 31,000 | 31,000 | 100 |
| Asbestos Abatement | 27,000 | 7,000 | 26 |
| Analytical Services | 25,000 | 12,000 | 48 |
| Instruments | 13,000 | 6,000 | 46 |
| Alternative Energy | 20,000 | 10,000 | 50 |
| **Total** | **814,000** | **491,000** | **60** |

Source: Ferrier, 1992, p. 7.

## What Jobs Do Environmental Technicians Perform?

The responsibilities of EHM technicians and related workers span a range of activities required for the safe handling of environmental hazardous materials and waste. For example, at a DOE facility, these activities often include hands-on tasks such as field sampling and testing materials for hazardous chemical or radioactive content; preparing labels or manifests that are required by regulation; developing and reporting information for local, state, and federally required publications; and working with waste generators to ensure compliance with facility, state, and federal requirements. Technicians working in the private sector—whether for consulting firms, wastewater treatment facilities, or in other industry sectors—generally perform similar environmental duties, although they are much less likely to be dealing with radioactive substances.

In the emerging environmental work force of the 1990s, technician-level personnel are employed in dozens of jobs, each one identified by a distinct job title. Our interviews at DOE facilities with presidents of environmental services firms and with managers working at hazardous waste generators produced a list of well over one hundred specific titles for environmental technicians and related workers. Many of these jobs are highly specialized and narrow in their respective duties and responsibilities. However, this plethora of job titles is a reflection of both the true diversity of these jobs and the frequent "overspecificity" in assigning job titles. That is, many jobs with varying titles actually include all or nearly all of the same job duties. For example, in one setting, a job may be called environmental technician, while in another it may be designated hazardous waste technician. Yet, employees in both jobs are required to perform essentially the same duties.

Despite this diversity of job titles, there are a few broad categories of environmental work into which most technician titles can be classified. Jobs in such categories share many of the same functional responsibilities, although actual job duties will vary by level, type of organization, and the objectives of a particular job assignment. The following discussion begins with a generic description of a hazardous waste management technician that is based on the U.S. Department of Labor's *Dictionary of Occupational Titles* (Chronicle Guidance Publications, 1985). It demonstrates the broad responsibilities that a technician specializing in hazardous waste management can assume. However, this comprehensive definition goes far beyond describing any actual job in a firm or an agency because it covers a much wider range of duties than those generally performed by any single technician.

These classifications were developed by researching the environmental programs conducted by various government agencies and analyzing the types of activities mandated by federal legislation. From these descriptions, functional categories of environmental hazardous materials (EHM) work were created. For example, the DOE Five-Year Plan establishes an environmental agenda for its facilities, including activities performed in four distinct fields of EHM work (U.S. DOE, 1989a). Similarly, an EPA report traces recent environmental reclamation activities, classifying their outcomes by the types of tasks that were performed (U.S. EPA, 1988). Finally, legislative efforts have also created the need for specific technician classifications with responsibility for transportation of hazardous wastes and emergency response activities.

### *A Generic Definition of a Hazardous Waste Management Technician*

According to an occupational guidance report based on the *Dictionary of Occupational Titles* (Chronicle Guidance Publications, 1985), hazardous waste management technicians

> provide information and advice on ways to collect, transport, handle, store, and dispose of toxic wastes. They help monitor and direct the cleanup of land, water, and air. These technicians survey industries to learn what disposal methods they use. They look at hazardous waste treatment disposal from the standpoint of both effectiveness and cost. From their findings, they make recommendations for ways to collect, move, store, treat, and dispose of these wastes. They offer advice and technical aid to members of industry and government.
>
> To help protect people and the environment, hazardous waste management technicians, especially those who work for the state or federal government, draft rules and regulations for handling hazardous wastes. They help to develop programs to prevent spills of hazardous waste. They review company or agency plans for spill prevention, and they may suggest changes in those plans. They help develop regulations for the reporting of spills and for measuring environmental damage caused by those spills. (p. 4)

### *Remediation*

Technicians involved in remediation activities work at contaminated waste sites to restore environmental and ecological integrity. Some have direct contact with waste materials, including physically unearthing, removing, or transporting wastes at the site. Others are responsible for creating, installing, or operating a waste reduction process through the use of chemical, physical, biological, and thermal techniques. Some of the most common job titles for technicians and related employees in this group are remediation technician, hazardous waste operator, material handler, chemical operator, chemical technician, or hazardous waste hauler.

### *Corrective Activities*

Technicians working in corrective activities are responsible for bringing facilities producing hazardous emissions and other waste into compliance with current government regulations and institutional controls. These individuals apply their knowledge of the complex regulations that determine standards on processes and emissions and are involved in removing inadequate systems and replacing them with systems that meet regulatory requirements. Individuals with such job titles as hazardous waste coordinator, air quality technician, or environmental technician participate in corrective activities as do technicians with specialized responsibilities for lead abatement and asbestos removal.

### *Waste Treatment and Management Activities*

Technicians involved in management and treatment activities work in facilities that are currently producing wastes. As part of their jobs, these employees manage wastes as they are produced, according to RCRA regulations and other related legislation. Duties in these jobs include monitoring waste producing systems to ensure control and safety; treating wastes to reduce their toxicity to levels acceptable for disposal, incineration, or storage; and preparing and packaging wastes for either future removal or treatment. Waste treatment activities such as remediation techniques include chemical, physical, biological, and thermal processes. Such classifications as liquid or solid waste treatment technician, solid waste site worker, and hazardous waste management technician are three titles in this classification.

### *Source Minimization and Recycling*

Source minimization and recycling activities are designed to reduce waste and pollution or convert these substances into other usable forms. Some technicians working in this field are involved in waste separation/segregation according to chemical properties, physical properties, or degree of hazardous elements. As a next step, these technicians prepare the resulting elements for reuse, resale, transport, treatment, or disposal. Recycling coordinator, recycling technician, and hazardous waste transportation technician are typical job classifications in this area.

### *Disposal Activities*

Technicians who are responsible for the disposal of hazardous wastes may perform a variety of duties. For instance, they may be involved in the creation and preparation of disposal facilities; the physical implantation of wastes in a facility; or a daily maintenance, monitoring, and record keeping at a disposal facility.

### *Monitoring Activities*

Technicians carrying out duties related to monitoring hazardous emissions and wastes may be employed by regulatory agencies, private environmental consulting firms, and in-house corporate waste management divisions. Monitoring activities can be performed on sludge/wastewaters, air/ambient emissions, and solid wastes at a variety of sites, including disposal facilities, industrial factories, public waterways, and real estate development sites. Technicians are responsible for taking samples, maintaining sample purity, and utilizing analytical devices. Sampling technician, laboratory technician, field technician, and liquid and solid waste technician are job titles that are commonly found in this area.

### *Transportation Activities*

Many people in the transportation industry are also indirectly working in the hazardous materials industry because they are required to handle the hazardous wastes and materials they transport in a specified manner. To perform their jobs, these technicians must have knowledge of U.S. Department of Transportation regulations controlling the shipment of such materials. Such multifunctional technicians include hazardous waste haulers, truckers, and hazmat coordinators who are all employed in the trucking, railroad, merchant marine, and airline industries.

### *Emergency Response Activities*

A variety of technicians are trained for emergency response to chemical, radioactive, and toxic spills. These technicians perform functions intended to contain, reduce, and limit environmental and public exposure to hazardous materials. This category contains a diverse array of job classifications, including certain fire fighters, emergency response technicians, and emergency response specialists as well as spill response technicians and coordinators.

## Results of Intensive Interviews with Managers and EHM Technicians

### The Interview Sample

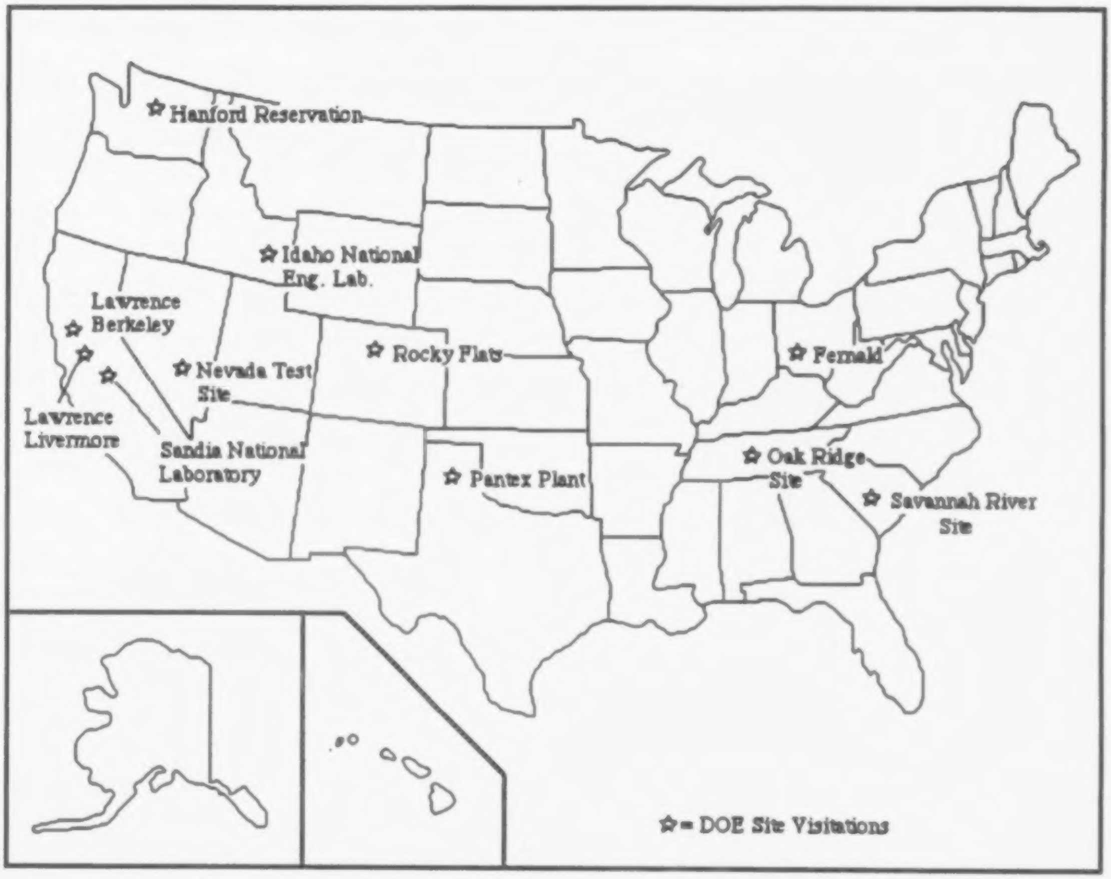
After completing a review of the literature about major educational and employment issues in the environmental field, MPR staff conducted intensive interviews with 144 managers and technicians at eleven Department of Energy facilities and with ten private-sector employers. See Appendix A for a list of these facilities and organizations. These interviews were designed to gather information about specific employment issues and to generate a preliminary list of occupational skill requirements for EHM technicians and related workers. The survey tools used for both the public- and private-sector intensive interviews are included in Appendices B and C. In conducting these one-hour, structured interviews, research staff identified the following:

- job classifications and titles of EHM technicians
- skills, knowledge, and abilities required for job performance
- current and expected employment needs for EHM technicians
- managers' recent experiences in hiring and retaining technician-level environmental personnel

At DOE sites, study staff conducted interviews with both DOE personnel and major contractors, although the great majority of interviews were held with contractor personnel who have more direct experience with employment issues related to technicians. Interviewees included technicians, their supervisors, and department managers. Within the private sector, the researchers held intensive interviews with representatives from twenty private firms. The professional titles of these individuals varied greatly. These individuals were presidents and principals of environmental consulting firms, managers of corporate waste management divisions, and supervisors of EHM technicians and related workers.

Figure 2 shows the geographic distribution of the DOE intensive interviews that were conducted nationwide. Interviews with DOE personnel were held in all regions of the country and at all major types of DOE facilities, providing an excellent representation of environmental technicians and their supervisors and managers. However, because of the limited resources of this study, we were unable to achieve an equally broad geographic distribution for interviews with private-sector representatives. Nevertheless, for these interviews, the research staff explicitly selected private employers that perform environmental services work throughout the United States (such as environmental consulting firms and remediation contractors that serve many different industries nationwide) or that have operating divisions in various parts of the country.

**Figure 2**
**Geographic Distribution of DOE Intensive Interviews**


☆ Hanford Reservation
☆ Idaho National Eng. Lab.
Lawrence
☆ Berkeley
☆ Nevada Test Site
☆ Rocky Flats
☆ Fernald
Lawrence Livermore
Sandia National Laboratory
☆ Pantex Plant
☆ Oak Ridge Site
☆ Savannah River Site
☆ = DOE Site Visitations

### Major Findings from Intensive Interviews at DOE Facilities

At every DOE site, it was observed that technicians and craft/hourly workers with EHM responsibilities are widely distributed across many divisions and departments. In addition, when conducting the on-site interviews, MPR staff asked managers if there were other areas of the facility where EHM technicians and workers are employed. Their responses indicated that additional EHM personnel are located in many organizational sectors that had not been identified initially by our contacts at each site. It was found that the exact locations of EHM personnel vary depending on the functional activities at each facility. The following are some examples:

- At the Savannah River Site in South Carolina, MPR staff conducted interviews in the Nuclear Materials Processing Division–Waste Management Operations and Environmental Restoration departments. While on-site, we were informed that EHM technicians and workers are also likely to be located in the Reactor Restart Division, the New Production Reactor Program Division, and the Environmental Safety, Health, and Quality Assurance Division.

- At the Fernald Site near Cincinnati, Ohio, study staff interviewed personnel from the Site Services programs and the Industrial Radiological Safety and Training program. We later concluded that five out of thirteen programs at Fernald are likely to employ EHM technicians and related workers. Among these five are also the Environmental Restoration, the Shutdown, and the Environmental Management programs.

- At the Nevada Test Site near Las Vegas, most EHM technicians and workers are likely to be located in the Environment and Health Division. Within that division, interviews were conducted in the Occupational Safety and Fire Protection Office, the Environmental Compliance Office, the Defense Waste Management Department, the Health Physics Department, and the Industrial Hygiene Department. Study staff also conducted interviews in the DOE's Human Resources Division.

Findings from these site visits also revealed that many facilities are currently restructuring to accommodate the dynamic nature of new, ongoing environmental projects and programs. Consequently, even the division and department locations of

EHM technicians and workers that we previously identified are now changing or may change in the near future.

## The Current Supply of EHM Technicians and Workers

### *Backgrounds and Education of EHM Technicians*

Interviews with managers, supervisors, and technicians included two sources of information relevant to understanding the current backgrounds of EHM technicians and related workers as well as the education, training, and experience that managers require of these employees. First, employees answered questions about their educational backgrounds and experience in EHM-related jobs. Second, managers and supervisors identified the skills and backgrounds of employees currently working for them, the backgrounds of those who had performed especially well in entry-level jobs, and the backgrounds that they believed EHM technicians and related workers should have to perform effectively.

The actual backgrounds and experience of employees working as EHM technicians and related workers were found to be astonishingly diverse, even in the same job classification at the same facility. For example, chemical operators at Rocky Flats included high school graduates, individuals with a few EHM-related courses at Front Range Community College, and an individual who had nearly completed a master of science degree in geology. The high salaries paid to chemical operators—resulting in part from substantial and highly paid overtime—was cited as a major incentive attracting well-educated individuals to these positions.

Similarly, at Lawrence Livermore National Laboratory in Livermore, California, two EHM technicians with closely related responsibilities in the same department had very different backgrounds. One individual, classified as a chemical materials science technician, was working on a waste management certificate at the University of California at Davis while the other, classified as a chemical technologist, held a bachelor of science degree in geology. However, the former employee had extensive related experience working for a private waste management firm.

Despite this variation, we observed that a very high proportion of the employees interviewed had completed some postsecondary school education, particularly in fields requiring the study of science and mathematics. Among the examples reported by the interviewers were two years of a mechanical engineering program, three years in a pre-pharmacy program, current participation in an EHM technician program, or completion of a two-year environmental engineering degree.

### *Ideal Backgrounds of EHM Technicians and Related Workers*

As with many other aspects of this study, there were some commonalities and many differences in managers' and supervisors' preferences with respect to the ideal backgrounds for these employees. For instance, management-level respondents strongly agreed about the importance of related job experience. However, "related experience" was very broadly defined, especially in the case of hourly workers. For hourly employees such as chemical operators, some managers indicated their preference for previous experience with other jobs at the same facility, even when those jobs included little or no EHM responsibility. When asked why they preferred this kind of experience, these respondents indicated that general knowledge of the facility, its security regulations, and a current security clearance were important elements.

In other instances, managers cited the importance of more direct job-related experience. Most notably, prior experience working as a chemical operator was often cited as a good background for individuals moving into other EHM positions. Several respondents also indicated that relevant prior experience could include the co-op component of a community college EHM vocational program or work for a contractor (or subcontractor) in a related job function.

In terms of the education and training backgrounds that best prepare new employees for entry-level EHM positions, there was no consensus among the managers and supervisors who were interviewed. Their responses to questions ranged from *high school graduation only* to a *technical postsecondary degree* such as an associate of arts degree in Environmental Sciences. We suspect that some managers de-emphasized the importance of formal EHM education because too few job applicants had that background and because of the extensive on-site training capabilities of many DOE facilities. However, when the interviewers probed further about the potential value of a technical EHM education if it were available, many managers indicated that such education would be desirable, but only if it included relevant work experience.

### *Recruitment Sources for EHM Technicians*

Our interview revealed that EHM technicians and related workers are recruited from many different sources and that these can vary from one DOE site to another. However, former nuclear navy personnel appear to be a frequent recruitment source for many DOE locations and one that receives very positive evaluations from management. In addition, DOE facilities themselves provide pools of trained technician-level workers for other DOE locations. Several managers indicated to us that many skilled EHM technicians, especially those with baccalaureate degrees, move from one facility to another as a way of upgrading their positions. However, it was also observed that some individuals with more limited EHM educations but prior DOE experience were also relocating to improve their job situation.

Local community colleges are also important recruitment sources for EHM technicians and related workers even though most of these programs have only recently started. In particular, managers at the Idaho National Engineering Laboratory (INEL) indicated that individuals who completed programs at Eastern Idaho Technical College were in great demand, and managers at Oak Ridge stated that they regularly hire graduates of programs at Roane State College. Respondents from Front Range College near Denver stated that they were beginning to produce graduates with EHM training, and managers at Rocky Flats indicated that they anticipate hiring these individuals and were sending current employees to on-site and off-site programs developed by Front Range for upgrade training. It is important to note that high demand for graduates from these programs partly reflects the substantial input these employers have in shaping local community college curricula.

In some instances, demand for personnel is so great and community college programs so highly regarded that employees are hired after completing only one year of a two-year degree program. These students are particularly valuable for DOE contractors because they have had site experience as part of their co-op programs and they "know the ropes" in terms of the work environment at the DOE facility.

### *How Difficult Is Recruitment?*

Responses to questions about how difficult it is to recruit EHM technicians and related workers provided information about possible supply/demand imbalances in the labor market for these employees. As with other issues addressed in the intensive interviews, we found that recruitment experiences vary greatly across locations. In fact, managers within a single location sometimes expressed different views about how difficult it has been to recruit employees. These differences at a single location may reflect the need for some unique skill sets that vary from one department to another. The following are some examples:

- At the Lawrence Livermore National Laboratory in the Hazardous Waste Storage, Shipping, and Disposal Department, there currently appear to be enough applicants for radiation and EHM technician positions. However, management reported that they attempt to hire employees with both radioactive and chemical hazardous materials knowledge and experience so that employees can be rotated through a variety of departmental functions. In general, applicants have knowledge in only one of these areas, and this deficiency requires that the department provide extensive training. Managers strongly indicated that they were eager to hire community college graduates or others with both chemical and radioactive hazardous materials backgrounds.

- With the exception of one manager at Savannah River, all managers interviewed at the Savannah River, Fernald, and the Oak Ridge (Tennessee) sites indicated that it was not difficult to generate a high volume of applicants for open positions. However, while the numbers were sufficient, the skill level of applicants was not adequate. We suspect that some managers have a high level of tolerance for new hires with inadequate skills partially because of the training that is available to these individuals on site.

- At the Idaho National Engineering Laboratory (INEL), two human resource managers offered slightly conflicting views about the recruitment situation for EHM technician-level personnel. One manager indicated that it was difficult to find these employees. His partial solution had been to hire voc-tech students from Eastern Idaho Technical College who had completed programs in process technology, radiation technology, or health and safety. A second manager indicated that he had had little difficulty recruiting health physics technicians because well-qualified individuals are available from the Eastern Idaho program.

- At Lawrence Berkeley Laboratory in California, the Division Director of Environmental Health and Safety, the Site Restoration Program Manager, and the

Manager of Environmental Health and Safety Training all indicated that it was difficult to find and hire well-qualified individuals for EHM technician-level job openings.

There is another dimension to the recruitment issue that relates more to staffing plans than to the adequacy of recruitment pools. It is possible that in some instances recruitment difficulties are not an issue but staffing plans are. Specifically, some recruitment programs may place professional-level personnel in technician-level positions because management has not pursued qualified technicians for these positions. To address this issue, study staff asked managers whether they had professional employees who could be replaced by qualified EHM technicians. We observed the following:

- At Savannah River, some professionals are performing technician-level work because of the recency of the environmental restoration program and management's desire to have more highly skilled personnel to initiate a new program. If this were the case, effective recruitment programs for technicians may alter this situation in the future.

- There are several areas at the Nevada Test Site where technicians could be doing work that is now performed by professionals. For example, environmental compliance coordinator positions are now being filled by professional geologists, but they could be filled by individuals with two-year EHM degrees. Similarly, some industrial hygiene and health physics technician positions that are now being filled by individuals with four-year degrees could be filled by employees with associate degrees.

- A manager at the Rocky Flats facility near Denver, Colorado, indicated that associate degree graduates from Front Range Community College would be excellent candidates for waste coordinate positions that are now being filled by individuals with baccalaureate degrees.

### Skill Requirements for EHM Technicians

Study staff set two objectives for the analysis of skill requirements in EHM technician and related jobs:

1. to identify the fundamental technical and nontechnical skills, knowledge, and abilities that are required for acceptable job performance in entry-level positions, and

2. to identify the unique skill sets that can be used to differentiate among functional groups of EHM technicians and related workers.

Both objectives are designed to provide educators, designers of training programs, and human resource planners with information that is necessary for strategic and operational program planning. Specifically, information on the fundamental nontechnical skills required for EHM technician jobs can be used to determine the basic education courses at community colleges, such as mathematics or English/communications, that should be required as part of two-year certificate or associate degree programs. Similarly, the specific technical skills that EHM technicians must acquire form the foundation of technical courses that make up a community college curriculum for this occupation. It is important to emphasize that the data collected for this study is not at the level of specificity of job competencies. Instead, they are at the slightly higher level of aggregation that is the precursor of job competencies. Appendix D includes the complete list of important skills, knowledge, and abilities that were gathered from the intensive interviews.

### *Technical Foundation Skills, Knowledge, and Abilities*

The skills list for EHM technicians and related workers derived from the intensive interviews indicates that there are four possible foundation areas of technical knowledge: chemistry, geology, mathematics, and physics. Taken together, these four fields of knowledge traditionally fulfill basic education requirements in most community colleges. Although all of these knowledge and skill areas were mentioned as important in several interviews, chemistry clearly emerged as important for the largest number of jobs. Specifically, respondents in both management and technician-level positions emphasized that technicians and related workers must know about chemical interactions and compatibility, chemical properties, and especially chemical principles that are applied to hazardous materials.

### *Nontechnical Foundation Skills, Knowledge, and Abilities*

The intensive interviews produced a list of seven nontechnical skills and abilities, including communications skills (written and verbal), teamwork, problem solving, comprehension of technical material, and work habits (teamwork and time management). In addition to these cognitive and socialization-related skills, a number of respondents indicated that the ability to lift heavy objects is important in many work settings.

Effective written and verbal communication emerged as the most important nontechnical skill requirement. In fact, these foundation skills were mentioned more frequently than any other technical or nontechnical skill on the entire inventory. Several managers said that communications skills were particularly important because of regulatory requirements for maintaining scrupulously accurate records and the complexity of directions that must be followed in EHM technician jobs.

### *Specialized Skills*

As Appendix D demonstrates, there is a long list of specialized skills that some managers, supervisors, technicians, and related workers consider important for effective performance of environmental technician jobs. Many of these were frequently identified in interviews for jobs in the functional groups proposed earlier in this section. The following are examples of these groupings:

- *Environmental remediation*: for example, soils and groundwater characterization, land surveying techniques, ability to read maps, and in-depth knowledge of geology

- *Corrective action*: for example, knowledge of EPA regulations, including CERCLA and RCRA, and knowledge of OSHA hazardous waste operations regulations

- *Environmental waste treatment and management*: requirements for packing waste and methods of pumping hazardous materials

- *Monitoring and surveillance*: use of specific monitoring devices (e.g., a photoionization detector) and knowledge of sampling methods

- *Emergency response/first response*: fire fighting skills, first aid, and management of evacuation activities

- *Transportation*: knowledge of Department of Transportation hauling requirements

### *Retraining Versus New Hires for Technician-Level Jobs*

One of the specific questions that study staff addressed in interviews with DOE and contractor management at DOE facilities concerned the practical issue of whether current employees have the basic skills to be retrained for environmental technician jobs. Our interview findings indicated that at several locations there already is substantial mobility from hourly or craft positions into technician-level environmental jobs. In fact, as was indicated earlier, many managers told us that they value on-site experience in other lower-level positions as a good background for new technicians. By completing a combination of in-house training and community college courses, these employees have been trained to perform as technicians.

However, research staff also observed that relatively strong backgrounds in math and chemistry (with a particular emphasis in algebra and trigonometry) and a solid knowledge of complex federal regulations are crucial for performing EHM-related jobs. Consequently, retraining programs will need to identify employees with these math and science backgrounds, or they will have to provide opportunities for individuals to study these subjects. These interview findings suggest, at least tentatively, that programs to retrain and upgrade current employees may be an effective method for increasing the technician-level work force at DOE facilities but that such programs must contain both basic and technical skills components.

## Major Findings from Intensive Interviews at Private Firms

Interviews with private industry managers focused on three major issues related to training and employment of EHM technicians: (1) factors affecting employment demand in the EHM field, (2) skill requirements necessary to utilize current technologies, and (3) recent recruitment experiences. The first of these issues was addressed at length earlier in this report. In the following section, we present interview findings on skill requirements and recruitment experiences.

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### *EHM Technician Skills Needed by Private Sector Employers*

Every manager that was interviewed stressed the importance of adequately trained personnel to meet the needs of the EHM field. They cited the potential physical dangers, monetary costs, and environmental damage that can result from having unqualified personnel in the field. Managers acknowledge that a foundation of work-readiness skills and job-specific knowledge is necessary to perform the duties and tasks associated with technician-level work. Technicians should possess basic professional skills, knowledge of industry specific sciences, and the ability to apply science to the processes that produce and transform wastes.

Because of the variety of private waste-generating and consulting firms in our sample, research staff encountered a highly divergent set of specific tasks that were required of EHM technicians. For example, researchers found that environmental consulting firms usually specialize in one of the eight major functional areas of EHM work identified previously. As a result of this specialization, the tasks required of technicians at such firms are very specialized. For example, a firm might specialize in transporting and cleaning or disposing of tanks that contain hazardous materials. Specific knowledge of underground tanks is required for these jobs but would be unnecessary in many other technician-level positions. In contrast, waste-generating firms are responsible for handling and monitoring their waste production processes at all stages. Consequently, study staff observed that technicians working for waste generators tended to need a wider variety of specific skills.

We were also interested in learning about managers' experiences with technicians from various educational and training backgrounds. A majority of these respondents indicated that associate degree programs are one of the best forms of technician training, while they perceived other educational backgrounds to have major drawbacks. For example, several managers charged that baccalaureate-level personnel have career aspirations that cannot always be fulfilled in their organizations, at least not in a short period of time. Many of these managers also indicated that the costs related to retraining applicants moving into the field or training high school-level applicants are too high for employers to bear. Among each of these respondents, the findings suggest that the level of job-specific training and general academic skills that are the focus of associate degree programs most adequately meet managers' skill requirements.

With regard to specific academic aptitudes, virtually all managers considered chemistry and biology to be very important. In order to minimize risks, technicians must understand the chemical nature of the waste products handled. They must also recognize the biological effects of chemical elements upon the environment and living organisms. Other academic fields were emphasized as they related to the specific field of EHM work. For example, a firm specializing in remediation activities would require knowledge of engineering and geology that could be applied to the creation and implementation of remediation systems. Conversely, an emissions monitoring and testing firm would desire applicants to have a background in physics and mathematics. Such skills are necessary to trace the paths of emissions through various environmental mediums (i.e., air, soil, and water).

### *Recruitment Experiences for EHM Technicians*

The educational backgrounds of the technicians at the firms visited varied dramatically. Most firms recognized that in the past they had been forced to hire overqualified technician-level personnel. In some cases, individuals with advanced degrees in hydrogeology and engineering were hired because applicants with lesser education did not have the specific skills required. Recently, some firms have begun to provide in-house training to applicants with more limited academic backgrounds and to search for educational systems that provide appropriate levels of training.

Most firms interviewed had experienced increasing need for technicians, especially since the passage of recent legislation. Further, most managers expected that, at the very least, there would be a steady increase in the number of technicians needed in the future. Many managers encountered difficulty identifying a source of adequately and appropriately trained applicants. Consequently, they have had to retrain unskilled applicants for industry-specific skills. Although most managers indicated that an associate degree was an appropriate level of training to suit their needs, none of the respondents stated that they actually knew of a school that offered such programs or that they had been able to recruit students who had received such training.

## Results of Employer Surveys

After completing the 144 intensive interviews with environmental technicians and managers working at DOE facilities or for private industry, the researchers used the list of important skills, knowledge, and abilities required of EHM technicians to create a job analysis questionnaire. This questionnaire listed all fifty-four specific skill, knowledge, or ability areas that were mentioned as important during the interviews. Appendix E includes the job analysis questionnaire that was created from these interviews. The questionnaire respondents were then asked to indicate how important each skill was for EHM technicians to perform their jobs. In this same questionnaire, they were also asked to respond to a set of questions about labor market and employment issues.

### Sample Selection for the Job Analysis Questionnaires

Choosing individuals to complete a job analysis questionnaire is different from selecting a probability sample that will be used to generate quantitative statistics and estimate population parameters. In the job analysis process, sample selection is directed at gathering input from a group of highly knowledgeable individuals who have specific expertise about a job or set of jobs. However, these respondents or experts are not likely to be statistically representative of all incumbents of the job that is being analyzed or of managers and supervisors who oversee these job incumbents.

With this objective in mind, study staff selected survey respondents by using a type of "snowball" sampling technique. That is, we first identified individuals whom we knew had expert knowledge about environmental technician jobs and asked them to complete the questionnaire. Then we asked these individuals to suggest additional experts who might also be willing to complete a job analysis questionnaire. Although it was not our intention to generate a probability sample in selecting respondents at DOE facilities and in the private sector, we attempted to identify individuals with the broadest range of functional responsibilities as possible.

The researchers developed two samples for the employer survey, one from DOE sites and another from environmental services companies and firms that are hazardous waste generators. We selected the DOE sample from the facilities where the intensive interviews were conducted because we knew that these sites represented all major types of DOE facilities.

In order to gather job analysis and employment-related information from DOE locations, two sets of questionnaires were mailed to prospective respondents. The first group was sent to about two dozen of the most knowledgeable managers who had been interviewed. These managers were chosen because of their demonstrated in-depth knowledge of the EHM technician job function. We also asked these individuals to recommend other managers at their facilities whom they considered to be experts and, therefore, knowledgeable respondents. These nominees received the second set of questionnaires.

To select the survey sample of private-sector environmental services firms and hazardous waste generators, a similar approach was used. First, questionnaires were sent to the most knowledgeable managers who had been interviewed, and they were asked to complete job analysis questionnaires. Second, we asked these respondents to suggest managers in large firms that were hazardous waste generators or principals in small environmental companies whom they considered to be experts and, therefore, knowledgeable respondents. Finally, we contacted several members of the DOE-sponsored consortium of environmental firms, government agencies, and community college environmental programs, the Partnership for Environmental Technology Education (PETE). We asked these PETE members to recommend managers from participating companies who would be highly knowledgeable about EHM technician positions.

### *Survey Response*

We ultimately received usable questionnaires from 128 managers and supervisors of EHM technicians. These were equally divided between DOE and private-sector respondents. The industry distribution of survey respondents within the private sector was generally good with the exception of agriculture and mining, which had very low response rates. Table 8 shows the representation of responses from private industry.

**Table 8**

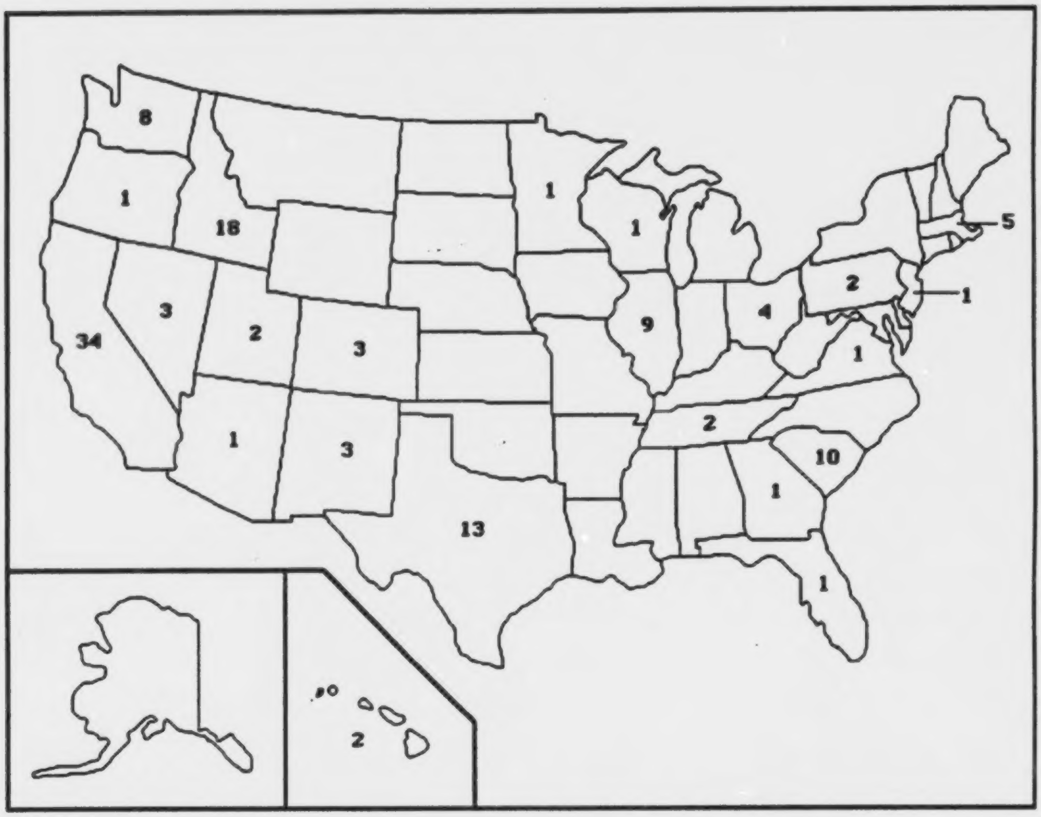
**Private Industry Respondents to Employer Survey, by Industry or EHM Field***

| | |
|---|---|
| **Hazardous Materials/Hazardous Waste Generators** | |
| 15 | Chemicals (solid, liquid, gaseous) |
| 4 | Metals |
| 2 | Minerals (coal, asbestos) |
| 10 | Radioactive solids |
| 1 | Biological |
| **Providers of Services to Generators** | |
| 4 | Landfill/Treatment plant operators |
| 5 | Treatment, storage, disposal |
| 6 | Characterization, storage, disposal |
| 12 | Remediation, cleanup, restoration |
| 2 | Transportation |
| 2 | Emergency response |
| 4 | Monitoring |

* Some respondents fall into more than one category.

The job analysis survey achieved an excellent geographic distribution of responses for DOE sites and a generally good distribution for private companies, given the fact that a snowball sampling method was used. The geographic distribution of all responses is illustrated in Figure 3.

Figure 3
Geographic Distribution of Survey Responses



Note: Two respondents did not provide geographic identification information.

## Research Findings

The following section presents the job analysis survey results and findings from questionnaires completed by environmental employers concerning other education and labor market issues. The discussion begins with a description of how employers rank the skills that are important for EHM technicians. Where there are important differences between the two groups, we also present and discuss separate sets of results for the two samples.

## Important Skills, Knowledge, and Abilities

In the job analysis portion of the employer questionnaire, employers were presented with a list of fifty-four skills, knowledge, and abilities that managers, supervisors, and technicians themselves identified in the intensive interviews. We asked these survey respondents to review the list and to indicate how important each skill is for effective job performance by technician-level environmental personnel. Response categories formed a Lickert scale, ranging from 1 ("not at all important") to 4 ("critically important").

On the questionnaire, the skills were grouped into three categories: nontechnical, general technical, and industry specific. These skills are shown in Table 9. Classification of items into these categories is largely a heuristic device used to facilitate respondents' thinking about the items as they complete the questionnaire and to help us discuss the results. In some instances, skill areas could easily be placed in more than one category. Consequently, for our purposes, evaluating the relative importance of the three categories and assessing respondents' ranking of individual items are both important.

## Table 9

## EHM Technician Skills, Knowledge, and Abilities

### *Nontechnical Skills*

Written Communication
Lifting Heavy Objects
Comprehension of Technical Material
Time Management
Verbal Communication
Problem Solving
Teamwork

### *General Technical Skills*

High School-Level Chemistry
Introductory-Level Geology
High School-Level Physics
Toxicology
Basic College-Level Chemistry
High School-Level Math
Basic College-Level Physics

### *Industry-Specific Skills*

Calibrating Detection and Survey Instruments
Constructing and Installing Gas Monitoring Wells
Hazardous Waste Handling
Conducting Helium Leak Testing
Taking Industrial Hygiene Measurements
Maintaining the Integrity of a Closed System
Maintaining Personal and Area Protection
Record Keeping
Responding to Radioactive Releases
Pumping Hazardous Materials
Monitoring Storage Facilities and Containers
Protocols for Handling Radioactive Wastes
Protocols on Hauling Waste Drums Safely
EPA Regulations, including CERCLA and RCRA
OSHA Hazardous Waste Regulations
Forklifts
Generators
Maps
Penetrometer
Land Survey Equipment
Site Evacuation
First Aid
Hazardous Waste Labeling
Maintaining Chain of Custody
Creating Maps from Photos
Packing Wastes
Reading Gauges
Responding to Chemical Spills
Sampling Hazardous Materials
Sampling Water and/or Sludge
Measuring Specific Gravity
Audio-Visual Equipment
Calibration Equipment
Cement Mixers
Earthmoving Equipment
Gas Chronometer
Large Vehicles
Monitoring Equipment
Radiation Detection Equipment
Volt Meter

Based on results of the survey, we calculated mean scores for each skill item and then ranked the fifty-four skills in terms of their mean level of importance. From this rank-ordered list, we divided the skills into ones that were in the top quartile, the middle fifty percent, and the bottom quartile in terms of level of importance. We repeated this process of creating quartiles from rank-ordered lists three times: once for all 128 respondents, including DOE managers and those from private industry; once for managers at DOE facilities alone; and, finally, for private-sector respondents only.

For all three of these rankings, we found that all of the skills that fell into the upper quartile had received mean scores of "very important" to "critically important" (between 3.0 and 4.0 on a four-point scale). Skills that ranked within the middle fifty percent received mean scores ranging between "somewhat important" to "very important" (between 2.0 and 3.0). Further, skills that ranked in the lowest quartile received mean scores of "not important" to "somewhat important" (between 1.0 and 2.0). Appendix F lists all fifty-four skills and their rankings by respondent type.

### *Nontechnical Skills*

On the employer surveys, we first asked respondents to indicate the importance of various nontechnical skills, knowledge, and abilities for effective performance of EHM technician positions. Nontechnical skills such as oral and written communication skills, teamwork, and time management closely parallel what have been called *foundation skills* in other studies such as the SCANS Report (Commission on the Skills of the American Workforce, 1990, p. 69). Overall, they represent the skills that all students should have as they progress through high school and prepare for entry into the work force.

We observed that employers consider nontechnical skills, as a group, to be more important for job performance than any other category of skills. These respondents indicated that six of the seven nontechnical skills on our list ranked in the top quartile in terms of importance, and three of the skills most desired by employers were comprehension of technical materials, teamwork, and verbal communications.

Table 10 displays the rankings of the nontechnical skills that are desired by all employers in our sample and also presents them separately for DOE managers and private-sector employers. These rankings demonstrate a very high degree of agreement between DOE managers and those from the private sector concerning the importance of nontechnical skills. The Spearman Rank-Order Correlation Coefficient—which compares ranked lists for the two sets of employers—is a very high value of .88. The only differences observed between the two groups appear among the marginally less important nontechnical skills. Specifically, private-sector respondents placed slightly greater emphasis on written communication, problem solving, and time management skills than did their DOE counterparts.

**Table 10**
**Employer Rankings of Nontechnical Skills**

| Skills, Knowledge, and Abilities (SKAs) | Rank Order | | |
|---|---|---|---|
| | All Employers | DOE Employers | Private Employers |
| Comprehension of Technical Material | 2 | 2 | 4 |
| Teamwork | 3 | 3 | 3 |
| Verbal Communications | 4 | 5 | 2 |
| Written Communications | 6 | 9 | 5 |
| Problem Solving | 11 | 15 | 8 |
| Time Management | 13 | 18 | 11 |
| Lifting Heavy Objects | 34 | 30 | 34 |

⬜ = Upper Quartile
▒ = Middle 50%
▓ = Lower Quartile

*General Technical Skills*

General technical skills straddle the boundary between the nontechnical (or foundation) skills described above and the industry-specific skills that are critical for performing particular jobs such as knowledge of environmental regulations or the ability to use specific instruments. General technical skills or knowledge reflect capabilities such as communication skills that individuals usually develop through academic work. However, these technical skills are typically more important for performance of technical occupations rather than nontechnical ones. As a result, we anticipated that these skills would be important for the technical jobs that exist in the environmental industry.

In other studies such as the SCANS report (Commission on the Skills of the American Workforce, 1990), some of the items we classified in this general nontechnical group—for example, high school-level math and science—were viewed as foundation skills that are similar to communications or teamwork. In general, we agree with that classification approach. Certainly high school math is a field of knowledge that employers require of entry-level employees who are joining the work force in both technical and nontechnical jobs. However, for the purpose of this study, we combined high school math and science with knowledge of higher level math and science in the general technical skills category in order to facilitate employers' rankings of the importance of these skills.

It was somewhat surprising to find that employers responding to this survey consider general technical skills to be slightly less important than nontechnical skills. Table 11 displays the rankings of these items by all employers and shows separate rankings by managers at DOE facilities and private firms. None of the general technical skills on our questionnaire were included among the upper quartile of skills most desired by all employers. However, high school math—the one general technical skill that could reasonably be classified with nontechnical skills—was in the top quartile for DOE employers and was not far below that ranking for private-sector survey respondents.

The majority of general technical skills fell into the middle fifty percent of skills that employers consider important. In the aggregate sample, only basic college chemistry and introductory geology fell into the lowest quartile, and their very low rankings suggest that they are considerably less important than other general technical skill areas. Similar to findings for nontechnical skills, respondents from DOE sites and from private-sector employers display a high level of agreement concerning the relative importance of general nontechnical skills.

## Table 11
## Employer Rankings of General Technical Skills

| Skills, Knowledge, and Abilities (SKAs) | Rank Order | | |
|---|---|---|---|
| | All Employers | DOE Employers | Private Employers |
| High School-Level Math | ▨ 16 | 13 | ▨ 19 |
| High School-Level Chemistry | ▨ 22 | ▨ 23 | ▨ 25 |
| Toxicology | ▨ 33 | ▨ 29 | ▨ 32 |
| Basic College Chemistry | ▨ 35 | ▨ 35 | ▨ 30 |
| High School Physics | ▨ 38 | ▨ 36 | ■ [illegible] |
| Basic College Physics | ■ [illegible] | ■ 41 | ■ [illegible] |
| Introductory Geology | ■ [illegible] | ■ 45 | ▨ 40 |

☐ = Upper Quartile
▨ = Middle 50%
■ = Lower Quartile

### *Industry-Specific Skills*

Industry-specific skills are those areas that are directly related to effective performance in hazardous waste management jobs, and they reflect the competencies that are unique to these positions. These job-specific skills form the basis of curricula in academic environments; or they can be taught in job training programs, short courses, or through on-the-job experiences. However, they are not competencies that are part of general education programs in either high schools or postsecondary institutions. The level of importance that employers attributed to these industry-specific skills varied significantly. While many of these skills were included within the upper quartile in terms of relative importance, many others fell into the lowest quartile. Table 12 shows the rankings of these industry-specific skills by all employers in our sample and also presents them separately for managers at DOE facilities and in private companies.

Table 12 also demonstrates that DOE and private-sector managers often disagree on the relative importance of industry-specific skills. Some of these differences are obviously the result of the technical requirements of these two work settings, which reflect their varied operations and the different forms of hazardous waste that they handle. For example, the respondents from DOE facilities are more likely to stress the importance of knowledge about radioactive wastes and emergency response. However, in other cases, we cannot explain observed differences. For example, private-sector employers are more likely to stress responsibilities relating to sampling, measurement, and monitoring, but we do not know why DOE respondents consider these important EHM technician skills to be less critical for job performance. It is possible that DOE facilities have resident industrial hygienists, while many private firms do not.

### *Skill Differences among Categories of EHM Technicians*

In a final analysis of skill requirements, the researchers used cluster analysis techniques to determine if skill requirements vary across different types of work. For example, we attempted to determine the skills that differentiate among technicians working in remediation, disposal, or hazardous waste monitoring activities. Surprisingly, even though three different statistical clustering techniques were used, with very few exceptions, we were unable to isolate separate skill requirements for different functional areas. This finding has important implications for curriculum planning in educational programs. This suggests that a single core curriculum can adequately prepare entry-level technicians for a wide range of environmental jobs.

## Table 12

## Employer Rankings of Industry-Specific Skills

| | Rank Order | | |
|---|---|---|---|
| Skills, Knowledge, and Abilities (SKAs) | All Employers | DOE Employers | Private Employers |
| Record Keeping | 1 | 1 | 1 |
| Maintaining Personal and Area Protection | 5 | 4 | 9 |
| OSHA Hazardous Waste Regulations | 7 | 10 | 6 |
| Hazardous Waste Handling | 8 | 8 | 10 |
| Hazardous Waste Labeling | 9 | 7 | 12 |
| Responding to Chemical Spills | 10 | 6 | 15 |
| EPA Regulations, including CERCLA and RCRA | 12 | 11 | 16 |
| Maintaining Chain of Custody | 14 | 16 | 14 |
| Sampling Hazardous Materials | 15 | 25 | 7 |
| Reading Gauges | 17 | 17 | 17 |
| Protocols on Hauling Waste Drums Safely | 18 | 19 | 21 |
| Monitoring Equipment | 19 | 21 | 18 |
| First Aid | 20 | 20 | 20 |
| Sampling Water and/or Sludge | 21 | 32 | 13 |
| Monitoring Storage Facilities and Containers | 23 | 27 | 23 |
| Packing Wastes | 24 | 26 | 27 |
| Site Evacuation | 25 | 24 | 28 |
| Protocols for Handling Radioactive Wastes | 26 | 12 | 35 |
| Calibrating Detection and Survey Instruments | 27 | 28 | 22 |
| Responding to Radioactive Releases | 28 | 14 | 36 |
| Calibration Equipment | 29 | 33 | 24 |
| Maintaining the Integrity of a Closed System | 30 | 31 | 29 |
| Pumping Hazardous Materials | 31 | 34 | 26 |
| Radiation Detection Equipment | 32 | 22 | 38 |
| Taking Industrial Hygiene Measurements | 36 | 37 | 33 |
| Maps | 37 | 38 | 31 |
| Forklifts | 39 | 39 | 39 |
| Measuring Gravity | 40 | 40 | 44 |
| Constructing & Installing Gas Monitoring Wells | 43 | 50 | 37 |
| Generators | 44 | 43 | 45 |
| Gas Chronometer | 45 | 48 | 42 |
| Large Vehicles | 46 | 49 | 41 |
| Volt Meter | 47 | 42 | 40 |
| Penetrometer | 48 | 46 | 47 |
| Audio-Visual Equipment | 49 | 44 | 50 |
| Land Survey Equipment | 50 | 52 | 48 |
| Creating Maps from Photos | 51 | 47 | 51 |
| Conduct Helium Leak Testing | 52 | 51 | 54 |
| Earthmoving Equipment | 53 | 54 | 52 |
| Cement Mixers | 54 | 53 | 53 |

☐ = Upper Quartile
▒ = Middle 50%
▓ = Lower Quartile

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## Educational Requirements for EHM Technicians

One of the objectives of this study is to provide education policy recommendations concerning the need to establish new or expanded education and training programs for EHM technicians. These recommendations will focus on whether EHM technicians and related workers should be trained on the job, whether structured program development should occur in two- or four-year colleges, and whether short courses such as OSHA training and other individual courses on technical material should play a role in developing an environmental technician work force.

To address these issues, the employer questionnaire included two assessment items:

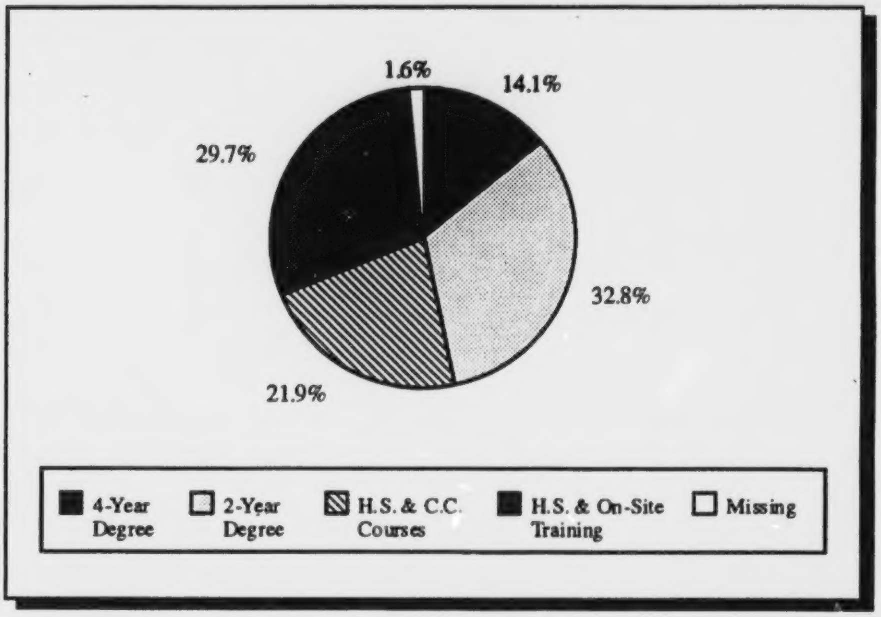
1. a question asking respondents to describe the level of education or training that they believe is necessary for individuals to perform technician-level environmental jobs and

2. A series of questions asking managers and supervisors to identify how each of the fifty-four occupational skills is best learned—whether it is on the job, in a short course, at a two-year college, or in a four-year institution.

As Figure 4 demonstrates, the great majority of employer representatives responding to this survey indicated that the level of education necessary for EHM technician work is less than a baccalaureate degree. Only fourteen percent of employer respondents stated that a baccalaureate degree was needed, whereas eighty-four percent believed that education ranging from a high school diploma to a two-year associate degree is adequate. Specifically, one-third stated that a two-year college degree would best qualify an applicant for EHM technician work. Moreover, fifty-one percent indicated that a high school diploma in conjunction with either limited community college coursework or on-the-job training would best prepare new employees for EHM technician positions.

However, based on our intensive interviews with environmental managers, we believe that this latter figure is inflated somewhat by the limited availability of one- and two-year postsecondary environmental programs. Specifically, our interviews revealed that many managers would prefer an alternative to on-the-job training, but they must settle for this type of job preparation because their local area lacks a postsecondary educational program producing a sufficient, trained labor pool of EHM technicians and related workers.

**Figure 4**
**Employers' Desired Educational Attainment for EHM Technicians**



The survey of environmental employers provides further insight into the diverse types of education and training that contribute to preparing EHM technicians by indicating how skills that are critical to job performance are best learned. Table 13 shows employer responses to the question *how is this knowledge or skill best learned* for the fifteen skills that these managers ranked most important for job performance.

## Table 13

## Employer Responses Concerning How Critical Job Skills Are Best Learned

| | | Percentage Indicating Skill Is Best Learned* | | | |
|---|---|---|---|---|---|
| Skill or Knowledge Area | | on the job | in short course | in two-year college | in four-year college |
| *(Skills listed in rank order of importance)* | | | | | |
| 1 | Record Keeping | 35.9 | 37.5 | 10.9 | 2.3 |
| 2 | Comprehension of Technical Material | 17.8 | 29.7 | 29.7 | 10.2 |
| 3 | Teamwork | 48.4 | 39.8 | 1.6 | 1.6 |
| 4 | Verbal Communications | 18.0 | 27.3 | 35.9 | 9.4 |
| 5 | Maintaining Personal and Area Protection | 24.2 | 47.7 | 10.2 | 0.0 |
| 6 | Written Communications | 10.9 | 18.8 | 49.2 | 10.9 |
| 7 | OSHA Hazardous Waste Regulations | 6.3 | 51.6 | 18.7 | 5.5 |
| 8 | Hazardous Waste Handling | 11.7 | 56.2 | 14.8 | 8.8 |
| 9 | Hazardous Waste Labeling | 15.6 | 54.7 | 9.4 | 8.8 |
| 10 | Responding to Chemical Spills | 14.8 | 45.3 | 14.8 | 0.8 |
| 11 | Problem Solving | 40.6 | 23.4 | 19.5 | 7.8 |
| 12 | EPA Regulations | 12.5 | 41.4 | 21.1 | 5.5 |
| 13 | Time Management | 35.2 | 45.3 | 6.3 | 1.6 |
| 14 | Maintaining Chain of Custody | 37.8 | 37.8 | 5.8 | 5.8 |
| 15 | Sampling Hazardous Materials | 15.6 | 44.5 | 14.8 | 0.8 |

*** Percentages do not add to one hundred percent because respondents indicating multiple categories are not shown.**

These results clearly indicate that very few managers and supervisors view four-year educational programs as the best setting for technicians to learn the skills that are critical for their jobs. However, beyond that single point of general agreement, they differ substantially in terms of what they believe are the best educational formats for learning most important skills. This diversity of opinion exists across different types of skills as well as for individuals skills. For example, respondents often indicated that on-the-job training is best for acquiring skills such as problem solving and teamwork and for gaining knowledge of how to maintain chain of custody. In contrast, according to these individuals, knowledge of personal and area protection and of handling and labeling hazardous waste is best acquired in short courses. Finally, community college or other two-year programs frequently emerged as the best vehicles for students to acquire written and verbal communications skills.

In a related set of questions, the survey also assessed the extent to which current employees exceed the educational levels that employers consider necessary for job performance. Specifically, respondents were asked to indicate how frequently they have had to hire overqualified individuals because of a lack of applicants trained at the necessary level. Our interviews during the first phase of this study indicated that employing overqualified individuals can present significant productivity problems for employers. For example, in some instances, employers must compensate these employees at similar levels to their equally educated peers in order to fill critical job openings. Also in many cases, overqualified technicians expect to move rapidly into higher level positions, resulting in high turnover rates and frequent job vacancies. Results of the employer survey suggest that hiring overqualified employees may be a problem, but it does not occur with great frequency. Approximately twenty percent of our respondents indicated that they have had to hire employees who are overqualified because of inadequate numbers of appropriately educated applicants.

### Anticipated Demand and Current Supply of EHM Technicians

Much of this survey focused on the recent and current experiences of managers in hiring and supervising EHM technicians. However, we were also interested in learning about the future employment prospects of these individuals and whether employer needs are likely to be met. Consequently, the survey queried employers about their anticipated demand for EHM technicians and related workers over the next one to three years. Our results suggest that future demand will be strong. Of the 128 employer respondents, seventy-seven percent anticipated that they will need to hire additional EHM technicians in the next one to three years. Managers at both DOE facilities and private companies indicated about the same level of future demand.

Not surprisingly, given the educational preferences of the survey respondents, we found that demand will be especially strong for individuals who have completed community college certificate or associate degrees or who have been enrolled in environmental short courses. Of the ninety-eight respondents who expect to recruit more technicians, thirty-six percent indicated that the most desired level of educational attainment for these new hires would be a two-year associate degree in environmental management. Another twenty-six respondents (27%) stated that a high school graduate with community college coursework was most desirable. Table 14 provides complete results concerning employer demand for workers with various educational backgrounds.

**Table 14**

**Employers' Hiring Expectations Over the Next One to Three Years, by Preferred Educational Background**

| Level of Education Preferred | Additional Hires Expected? | | | | | |
|---|---|---|---|---|---|---|
| | Yes | | No | | Missing | |
| | # | % | # | % | # | % |
| Four-Year Degree | 14 | 14 | 0 | 0 | 4 | 20 |
| Two-Year Degree | 35 | 36 | 2 | 20 | 5 | 25 |
| High School & Community College Courses | 26 | 27 | 2 | 20 | 0 | 0 |
| High School plus On-Site Training | 23 | 23 | 6 | 60 | 9 | 45 |
| Missing | 0 | 0 | 0 | 0 | 2 | 10 |
| **Totals** | **98** | | **10** | | **20** | |

While demand for EHM technicians is likely to be very high over the next one to three years, many employers are already experiencing an inadequate labor supply. Seventy-seven percent of those surveyed indicated that they expect to hire more employees in the near future, but nearly two-thirds believed that recruiting qualified individuals to fill technician-level positions would be "slightly difficult" to "difficult."

Table 15 illustrates the recruiting experiences of employers. Of the eighty respondents experiencing difficulty recruiting EHM technicians, seventy-one individuals (89%) felt the best level of educational attainment for environmental technicians consisted of either an associate degree in the environmental field or a high school diploma augmented with community college coursework or on-the-job training.

Moreover, employers who felt that applicants with two-year degrees were the most qualified experienced greater difficulty recruiting EHM technicians than did any other category of employers. Less than one-quarter of all respondents felt that recruiting qualified applicants for technician positions was "easy." Among these employers, more than one-third believed that on-the-job training of high school graduates was the best form of education for the job, which most likely explains their relative ease in finding applicants.

These findings suggest that if the current supply of EHM technicians with postsecondary-level educations does not increase, employers will find it increasingly difficult to meet their employment needs for technician-level personnel. In addition, it is quite possible that more employers will have to resort to costly in-house training to provide this education for their technicians.

**Table 15**

**Employers' Experiences Recruiting EHM Technicians and Related Personnel, by Preferred Educational Background**

| Level of Education Preferred | How Difficult Was Recruiting? | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Easy | | Slightly Difficult | | Difficult | | Missing | |
| | # | % | # | % | # | % | # | % |
| Four-Year Degree | 5 | 15 | 4 | 11 | 5 | 12 | 4 | 22 |
| Two-Year Degree | 8 | 27 | 10 | 26 | 20 | 48 | 4 | 22 |
| High School & Community College Courses | 6 | 20 | 15 | 39 | 6 | 14 | 1 | 6 |
| High School plus On-Site Training | 11 | 37 | 9 | 24 | 11 | 26 | 7 | 39 |
| Missing | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 |
| **Totals** | **30** | | **38** | | **42** | | **18** | |

## Implications of Research Findings from Employer Surveys

Findings from the employer survey have several implications for environmental education programs and employment trends for technicians. Given the large percentage of employers who anticipate hiring additional technicians in the immediate and near future, demand should remain very strong and could rise substantially. Although we are unable to apply these results in any statistical fashion to the general population of environmental employers, they do suggest that there will be a significant need for more environmental technicians over the next three years. Considering the desirability of technicians with community college degrees and/or coursework, the anticipated demand for more trained technicians in the near future, and the difficulty that employers have experienced recruiting applicants with such training, there may be a substantial mismatch between supply and demand of qualified EHM technicians. Evidence from this employer survey suggests that existing or new programs should be aimed at educating larger numbers of technicians to perform environmental hazardous materials management activities. Specifically, degree and certificate programs as well as short courses and contract education courses should be developed within the community college network.

However, to target the needs of the local environmental employers, educators must survey their local industries to assess levels of demand and requirements for industry-specific skills. It is likely that different regions and localities will experience widely divergent employer requirements depending upon state and local regulations, regional industries, types of public facilities, and number of local Superfund sites. Based upon these and other factors, desired industry-specific skills can be determined and integrated into educational curriculum. In the case of nontechnical and general technical skills, the consistently high level of importance assigned to these skills by all employers surveyed indicates a strong need for them in all sectors, regions, and industries. These skills should form the core competencies of postsecondary environmental programs irrespective of the local industry mix of environmental employers.

# EDUCATION'S RESPONSE TO INDUSTRY NEEDS: FINDINGS FROM A SURVEY OF COMMUNITY COLLEGE EDUCATORS

## Background

### What Are Industry's Needs?

The previous section reported results from a survey of environmental employers that explored labor force and skill needs for EHM technicians and related workers. This section presents findings from a follow-up to that industry needs assessment: a survey of community college educators and program administrators intended to determine whether current education and training programs are meeting the needs of the environmental industry. This educator survey was designed specifically to address the following findings from the employer survey:

- A substantial majority of employer representatives from the private sector and managers at DOE facilities indicated that their demand for EHM technicians will increase in the near future and that their current staffing requirements often are not adequately met. Demand will be especially high for employees with community college-level training, but these individuals frequently are not available in sufficient numbers. Are community colleges expanding their environmental programs and enrollments?

- EHM technician positions span a broad range of technical and nontechnical job responsibilities. They range from positions with substantial manual labor requirements to ones demanding sophisticated knowledge of chemistry, legal regulations, and instrumentation. As a result, managers need to hire technicians with a common core of knowledge about environmental issues but also with varying levels of specialized knowledge. Because of the diverse skills required, there is no single credential or educational background that is ideal for individuals in all EHM technician positions. Furthermore, many individuals that retrain for EHM technician positions already hold technical associate or baccalaureate degrees and require only limited additional training in specific job skills. Taken together, these observations indicate that employers need access to a mix of education and training programs, including short courses, certificates, and associate degrees. Are two-year postsecondary institutions providing the kinds of education and training that employers need?

- Individuals who hold baccalaureate degrees in science or engineering and work in technician-level jobs are often overqualified for these positions. While they certainly can perform EHM technician jobs, they also have large turnover rates and may command salaries that are higher than necessary. As a result, to meet the current demand for technicians, educational programs should be expanded at the associate degree and certificate levels. Have community college programs planned to expand their enrollment, and are they attracting students to fill these openings?

- While EHM technician positions are highly technical in nature, they also require employees to have well-developed nontechnical skills in written and oral communications, teamwork, problem solving, and time management. As a result, educational programs must focus on developing both job-specific technical skills that are unique to the environmental industry and basic nontechnical skills that are the foundation of certificate and, especially, associate degree programs. Do community college curricula reflect this need for developing both technical and nontechnical skills and knowledge?

### Findings from Previous Studies on Environmental Education

During the literature review that was conducted at the beginning of this study, we identified several reports that support the preceding conclusions from the employer survey. The authors of these reports predict that demand for EHM technicians is expected to grow in the future and identify current shortages of technicians in many geographic areas (Bay Area Council & Bay Area Bioscience Center, 1991; Busch, 1988; Cain, 1990; Ferrier, 1992; McNulty, 1991; Saltzman, 1988). However, at the present time, there are virtually no studies that specifically address enrollments in EHM technician programs or the capacity of the institutions with EHM curricula to supply sufficient numbers of qualified EHM technicians in the future.

We encountered only one study that conducted comprehensive research into current educational capabilities to supply EHM technicians. That study, performed by Kummler, Witt, and Powitz (1990) of Wayne State University for the U.S. Department of Health and Human Services, surveyed nearly fifteen-hundred four-year academic institutions and hundreds of nonacademic institutions offering EHM courses. The report that culminated from this study contains information about EHM programs at responding institutions, including tuition and fees, types and duration of programs, and degrees/certificates awarded.

The focus of the Wayne State University study was to survey baccalaureate and graduate degree programs in hazardous waste management, not the type of programs that typically educate technician-level personnel. Consequently, community colleges were not included in the sample population. Results of this study confirm that there are relatively few four-year universities offering courses in environmental management and many fewer that offer degree programs. Interestingly, the researchers concluded that the majority of EHM training is currently delivered through continuing education short courses (Powitz, Kummler, Witt, & Hughes, 1990).

## Educator Survey

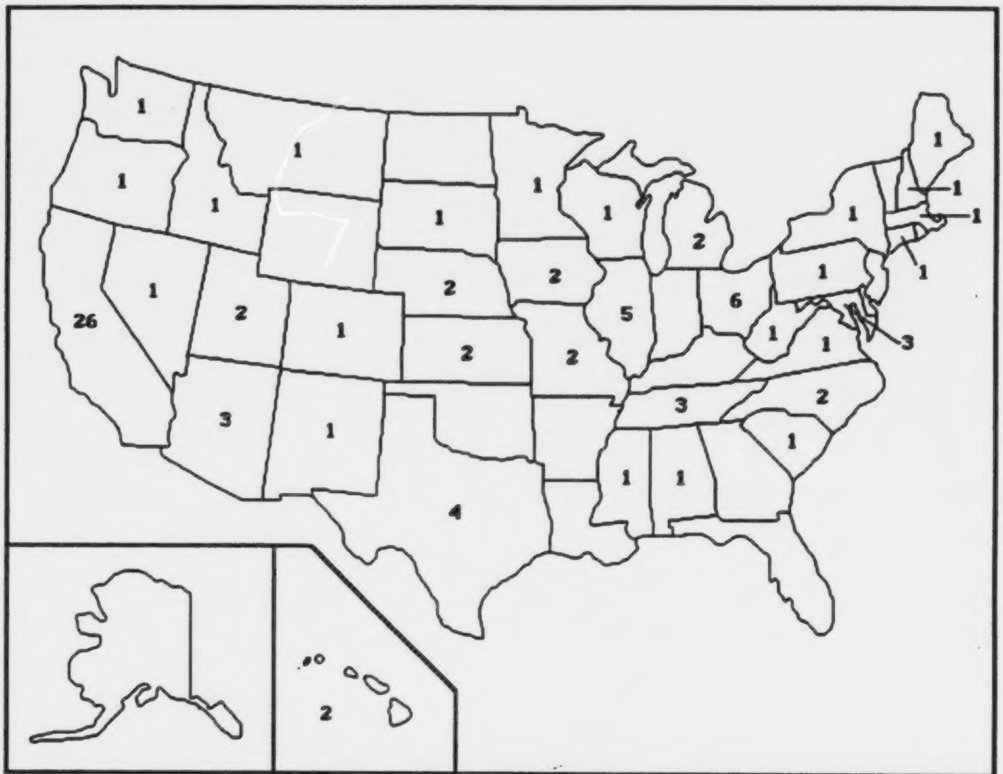
### Survey Methodology and Respondents

MPR staff developed and mailed out a questionnaire for environmental educators at public postsecondary institutions that paralleled the employer survey. The survey was designed to identify the fit between environmental curricula and the employers' needs that had been identified. It included the list of important skills, knowledge, and abilities that employers indicated are important for EHM technicians. The survey also included questions about educational programs, student characteristics, recruitment and placement experiences, and educators' assessments of the environmental labor market. This survey instrument is included as Appendix G.

Using a "snowball" sampling method similar to the one used for the employer survey, study staff selected a sample for the survey of postsecondary environmental educators. The researchers first identified all public educational institutions that were known to have some type of nonbaccalaureate environmental training or education program and then asked program coordinators at these institutions to complete a mail questionnaire. These respondents were then asked to recommend individuals at other institutions that provide similar environmental education, and questionnaires were sent to these individuals, as well. Finally, we asked all members of the Partnership for Environmental Technology Education (PETE) to suggest individuals at public institutions that offer nonbaccalaureate environmental education and training, and we added these educators to our sample. Using these three methods of identifying potential survey participants generated a sample of 166 institutions that the educators in our sample or other environmental educators believed were likely to offer environmental education and training for EHM technicians and related workers.

Obviously, by using this "snowball" sampling method, the research staff did not intend to generate a probability sample of institutions that would allow us to arrive at statistical generalizations about all similar environmental programs. Nevertheless, we attempted to identify a nationwide group of institutions that includes a broad range of public environmental education and training providers. As Figure 5 indicates, with the exception of the eastern United States, the snowball sampling method was effective in producing a good geographic representation of institutions and response rate. As a result of this distribution and high response rate, we are confident that these findings indicate major trends at a wide range of public institutions.

**Figure 5**
**Geographic Distribution of Educator Survey Responses**



Note: One response was received from the District of Columbia; the location of three other respondents cannot be determined.

### *Characteristics of Survey Respondents*

Ninety-four of the 166 institutions that we contacted responded to our survey, representing a fifty-seven percent response rate. These institutions were located in twenty-four states, with a particularly heavy concentration in California. Of these institutions, fifty-nine percent offer some type of environmental training for technician-level personnel, while forty-one percent do not offer any environmental programs. The great majority (eighty percent) of these environmental programs are offered by two-year community colleges, although it is important to note that four-year postsecondary institutions were explicitly excluded from the sample.

### Types of Programs for EHM Technicians

The institutions that responded affirmatively to our survey offer a range of program types, and many provide multiple types of programs:

- Thirty-one institutions (56.1%) offer two-year associate degrees.
- Thirty-two institutions (58.1%) offer short courses on campus that are open to the general public.
- Twenty-seven institutions (49%) offer short courses either on or off campus on a contract basis to individual employers.
- Seventeen institutions (31%) offer one-year certificate programs.
- Eight institutions (15%) offer semester-length courses that are not part of a certificate or degree program.
- Three institutions (6%) offer baccalaureate programs.

These findings suggest that the many types of environmental programs at two-year colleges help to satisfy employer needs for varying formats and levels of environmental education. Moreover, it is clear that academic institutions are targeting the needs of local industry by implementing various programs at their schools. This is true both across institutions in broad geographic areas and within individual institutions that serve a particular local labor market. Specifically, more than two-thirds of the respondents from institutions offering EHM courses in this sample offer multiple types of EHM programs. Frequently, these multiple-format curricula consist of one of two combinations: an associate degree program and on-campus short courses; or a degree or certificate program and contract education courses for employers. These findings suggest that community college educators are doing an effective job of identifying employer needs and meeting them.

These combinations of course delivery formats suggest that many institutions are meeting the diverse needs of their labor market. They are addressing these needs by providing comprehensive environmental education through certificate or associate degree programs and by providing the targeted short courses such as OSHA training and emergency response that employers require for entry-level workers and for retraining an existing work force.

**Student Recruitment and Enrollment**

Educational institutions have also been responding to industry's growing demand for environmental technicians and related workers by increasing their enrollment capacity. Over the past three years, colleges offering short courses, semester-length courses, certificates, and associate degrees have all increased their enrollment targets. As Table 16 indicates, depending on the type of program offered, at least sixty percent and sometimes as many as seventy-five percent of institutions have increased their enrollment targets during this period.

**Table 16**

**Changes in Enrollment Targets, 1990-1992, by Program Type**

| | Number of Institutions Where Enrollment Targets Have . . . | | | | | |
|---|---|---|---|---|---|---|
| | Increased | | Decreased | | Stayed the Same | |
| Program Type | # | % | # | % | # | % |
| Two-Year A.A. Degree | 18 | 67 | — | — | 9 | 33 |
| Two-Year Certificate | 4 | 67 | — | — | 2 | 33 |
| One-Year Certificate | 9 | 60 | — | — | 6 | 40 |
| Individual Semester Classes | 6 | 75 | 1 | 13 | 1 | 13 |
| Short Courses (Public) | 18 | 62 | 2 | 7 | 9 | 31 |
| Short Courses (Contract) | 16 | 67 | — | — | 8 | 33 |

— Indicates zero responses in that category.
NOTE: Total may not equal one hundred percent because of rounding.

Raising enrollment targets is only a first step toward increasing the supply of EHM technicians and related workers. Institutions that increase their enrollment targets—or even maintain constant enrollment expectations—can only be successful in meeting growing labor market demand if they are also able to attract sufficient numbers of students to fill openings in their programs. To address this issue, we asked educators about their success in filling program capacities. Table 17 presents survey findings on this issue.

**Table 17**

**Educational Program Experience in Meeting Enrollment Targets**

| | How Easy or Difficult Has It Been for Institutions To Meet Enrollment Targets? | | | |
|---|---|---|---|---|
| Year | Very Easy | Somewhat Easy | Somewhat Difficult | Very Difficult |
| 1989-1990 | | | | |
| Number | 11 | 18 | 9 | 1 |
| Percentage | 28 | 46 | 23 | 3 |
| 1990-1991 | | | | |
| Number | 13 | 22 | 9 | 2 |
| Percentage | 28 | 48 | 20 | 4 |
| 1991-1992 | | | | |
| Number | 14 | 24 | 7 | 3 |
| Percentage | 29 | 50 | 15 | 6 |

NOTE: Total may not equal one hundred percent because of rounding.

With relatively few exceptions, these institutions have been successful in meeting their targeted enrollments. In the three academic years—1989-1990, 1990-1991, and 1991-1992—about three-quarters of our respondent institutions indicated that they had reached enrollment targets "very easily" or "somewhat easily." During this same period, forty-three percent of responding institutions were able to translate increased enrollment targets into "moderate" or "large" enrollment increases. These findings indicate that although many of these programs are relatively new, student interest in the environment and knowledge about individual programs are high enough to meet enrollment capacities.

## Program Success in Meeting Labor Market Needs

As already indicated, employers anticipate hiring larger numbers of employees with technician-level environmental training, and many environmental programs at two-year institutions are already increasing their enrollments. The final step toward ensuring that educational programs meet labor market needs is converting high enrollments into correspondingly high graduation rates. In order to accomplish this objective, it is important to determine how successful these programs are in selecting and educating students who complete their environmental education programs. This survey suggests that success rates are generally high, although they could be improved. According to these respondents, sixty-five percent of students enrolled in two-year certificate programs graduate, fifty-eight percent of students in two-year certificate programs receive their certificates, and sixty-five percent of students in one-year certificate programs complete their course of study.

Students may fail to complete their programs for a number of reasons. Some of these reflect conditions in the environmental labor market, while others result from the inadequate academic preparation of some enrollees. Specifically, our respondents indicated that about fourteen percent of associate degree students and eighteen percent of those in certificate programs do not complete degrees because they are hired into environmental jobs before they can complete their educational programs. This situation reflects the high-demand conditions of the current labor market and the fact that many employers cannot wait to hire only degreed or certificated individuals.

Very different circumstances prevail, however, for other students who fail to complete their educational programs. Survey respondents indicated that twenty-eight percent of associate degree students and thirty-two percent of students in certificate programs drop out because they lack the fundamental math and science skills necessary for success in school. These high percentages suggest a need for more rigorous screening of program applicants or remedial programs that will increase student success rates. Table 18 shows complete survey responses that help explain the reasons students fail to complete associate degree and certificate programs.

## Table 18
## Reasons Why Students Fail To Complete Associate Degree and Certificate Programs

| | Percentage of Students Not Completing Program | |
|---|---|---|
| Reason for Leaving | Associate Degree | Certificate |
| Students lack fundamental math and science skills | 28 | 32 |
| Demands of school and work are too difficult to handle | 28 | 21 |
| Students are hired by eager employers before they complete the program | 14 | 18 |
| Students have financial problems | 13 | 16 |
| Students leave the area | 9 | 6 |
| Other reasons | 7 | 6 |

NOTE: Totals may not equal one hundred percent because of rounding.

### Student Characteristics

One of the major goals of current vocational programs is to broaden the participation of traditionally underserved groups in high technology fields requiring knowledge of math and science and offering future career advancement. These educational goals support the unprecedented need in today's economy to develop a skilled work force that reflects the full diversity of the American population. Occupations in the environmental field at either the technician or professional level clearly qualify as advanced technology positions. Not only do they require knowledge of math and several scientific fields, but they also provide opportunities for technical or management career advancement.

By identifying the demographic characteristics of students who are enrolled in environmental technician programs, this survey of environmental programs sheds some light on whether environmental programs are achieving the goal of educating a diverse student body. On the one hand, the institutions in this sample display a fairly substantial representation of female students, who make up about twenty-eight percent of the total enrollment. While this proportion is much lower than the fifty-seven percent of all students at two- and three-year postsecondary institutions who are female (Choy & Gifford, 1990, p. 12), it compares favorably with the proportion of females receiving associate degrees in mathematics (37%) and in the physical sciences (42%) (U.S. Department of Education, 1991, pp. 262-263). In contrast, minority and disabled students are not nearly as well represented in EHM technician programs. Moreover, only six percent of enrolled students are African American, nine percent are Hispanic, and two percent each are Asian/Pacific Islander or American Indian/Alaskan Native. Similarly, respondents to the survey indicated that only three percent of students can be identified as disabled.

Although these programs could improve their representations of minority and disabled students, they are nevertheless meeting the critical needs of our rapidly changing economy and labor market and continue to offer an avenue for adult students to enhance their careers or to change fields. This is a particularly critical role for these programs and an important part of the mission of community colleges in light of the structural changes occurring in the economy and the resulting organizational restructuring and job losses. However, environmental technician programs are not a frequent choice for students who are moving directly from secondary to postsecondary school. For example, only one-third of enrolled students are under twenty-five years old, while two-thirds are twenty-five years old or over.

To some extent, these figures reflect the larger trend in enrollments at two-year postsecondary institutions, where over fifty percent of students enrolled are over the age of twenty-five (U.S. Department of Education, 1991, p. 171). However, early in this study, several focus groups were conducted with environmental educators that do shed light on this finding. Several of these educators indicated that high school students know very little about the jobs that are available in the environmental field, especially those requiring a technical community college-level education. In addition, there is clear evidence that declining numbers of high school students are studying math and science at levels that are required for highly technical fields such as environmental studies (Ogle, Alsalam, & Rogers, 1991, p. 9). It is possible that this trend is also contributing to the relatively low number of high school students who enroll in community college environmental programs. Finally, some programs, like those in California, offer most classes at night and, therefore, attract a largely adult population of students.

On the other hand, older adults who are enrolled in these programs do see the career potential in the environmental field and are capitalizing on these opportunities by enrolling in community college programs. In some instances, it is employers who have recognized that community college programs can provide the environmental training that their employees need. According to our respondents, fully one-half of the students enrolled in their environmental programs are currently employed in jobs requiring knowledge of environmental issues, while about one-quarter are enrolled in environmental courses because they want to change careers.

### Are Educational Programs Meeting Employer Skill Requirements?

The employer surveys conducted in the first part of this study provide clear evidence of the nontechnical, general technical, and industry-related skills that employers consider important for EHM technicians and related workers. The educator survey followed up these findings by exploring the skills and knowledge that are important parts of environmental curricula in associate degree and certificate programs. Specifically, we presented educators in the sample with the same list of fifty-four skills that were evaluated by employers. We asked these instructors and program administrators to indicate how important each skill is as an objective of their curricula by responding from "1" to "3" ("not at all important" to "very important").

A comparison of the employer and educator surveys indicates that environmental educators and employers strongly agree about what skills are important. Among the thirty-three skills that employers ranked at least "important," twenty-two were considered "very important" for associate degree programs and eighteen were considered "very important" for certificate programs. Virtually all of the remaining thirty-three skills designated as "important" by employers were also "important" or "very important" learning objectives of community college curricula.

### Evaluation of Labor Market Demand

The employer surveys provided clear evidence that our respondents anticipate an expanding market for EHM technicians and related workers based on their own hiring expectations over the next one to three years. Research staff obtained two additional types of evidence bearing on current and future labor market demand from the educator surveys. First, these questionnaires asked respondents to indicate the three industries in their local area that employ the largest numbers of EHM technicians and whether employers in these industries will experience declining, stable, or increasing staffing needs in the next one to three years. Table 19 displays educators' responses to these questions about future demand for technicians.

**Table 19**

**Educator Assessments of Future Demand for Technicians, by Industry**

| | Over the Next One to Three Years Demand Will . . . | | |
|---|---|---|---|
| Industry | Decrease | Remain Stable | Increase |
| | | (percentage) | |
| Manufacturing (Durable) | 13 | 29 | 58 |
| Manufacturing (Nondurable) | 8 | 25 | 67 |
| Transportation/Public Utilities | — | 18 | 82 |
| Health Services | 8 | 17 | 75 |
| Environmental Consulting Services | — | 21 | 79 |
| Government | 12 | 36 | 52 |

— Indicates zero responses in that category.
NOTE: Totals may not equal one hundred percent because of rounding.

These results indicate that few educators foresee declining demand for EHM technicians in virtually any industry and that many anticipate widespread expansion in demand.

Second, the educator survey included a set of questions about the kind of employment market students faced when completing their programs last year. Specifically, educators were asked to indicate how easy or difficult it was for students to find employment in the environmental field. As Table 20 shows, with the exception of students in nondegree semester-length courses, finding a job last year was generally easy for most students. Considering the fact that these students were seeking employment during a recessionary period of high unemployment, these figures are especially impressive.

Table 20

Students' Experience Finding Employment Last Year, by Type of EHM Program

| Program Type | Very Easy | Somewhat Easy | Somewhat Difficult | Very Difficult |
|---|---|---|---|---|
| | | (percentage) | | |
| Two-Year A.A. Degree | 14 | 59 | 23 | 5 |
| Two-Year Certificate | 11 | 56 | 33 | — |
| One-Year Certificate | 8 | 54 | 31 | 8 |
| Individual Semester Classes | — | 50 | 50 | — |
| Short Courses (Public) | 7 | 53 | 40 | — |

— Indicates zero responses in that category.
NOTE: Totals may not equal one hundred percent because of rounding.

## Summary and Conclusions

### The Current Relationship Between Supply and Demand

Without a probability sample, it is impossible to estimate how many EHM technicians are currently employed or the future size of the EHM work force that government and industry will demand. Nevertheless, the two snowball samples of environmental employers and community college educators developed for this study provide clear indications about the current employment picture for these technicians and related workers. A substantial majority of employer representatives from both DOE facilities and private firms indicate that they anticipate hiring additional technicians in the next one to three years and that they are currently experiencing some difficulty filling current openings.

The severity of these recruitment problems is not extreme. However, in light of the recessionary economy that existed throughout the survey period and its resulting increase in the supply of available workers, the recruitment difficulties that emerged from our interview and survey data are particularly striking. They strongly suggest that the current supply of EHM technicians is not fully adequate to meet employer needs.

At the same time, community college environmental programs have experienced little difficulty meeting their enrollment targets, even when these targets have been increased. Moreover, students completing all types of environmental programs, including associate degrees, certificates, and short courses face excellent prospects for employment in jobs related to their environmental training. These observations that educators and administrators have made about the labor market provide further support for the conclusion that the current supply of environmental technicians may be only marginally sufficient to meet current employment needs.

## The Fit Between Employer Skill Requirements and Environmental Curricula

Based on the surveys of both employers and educators, there appears to be a strong fit between the skills that employers need when hiring EHM technicians and related workers and the skills that form the basis of community college environmental curricula. Analyses of job analysis questionnaire data from DOE and private-sector employers indicate that a single core of nontechnical and technical skills is critical for effective performance in nearly all technician-level environmental jobs. As a result, there is little need for highly specialized curricula designed to educate and train individuals for specific EHM technician positions. Similarly, a very high degree of overlap exists in the skills that most community college programs use in developing their course curricula.

Although there is substantial agreement concerning necessary occupational skills for technicians, employers need and want different educational formats to prepare workers with these skills. For example, some employers are recruiting new employees and expect them to be fully trained in the range of environmental functions, whereas others hope to retrain an existing work force that may already hold technical associate and baccalaureate degrees. However, a number of employers are seeking short courses on environmental subjects in order to upgrade the job skills of employees who are already working in environment-related positions. These multiple needs of employers underlie a demand for diverse types of environmental formats that include associate degrees, certificate programs, and short courses.

Once again, community college environmental programs appear to be meeting these disparate needs by providing a good mix of environmental courses. For example, in many instances, the same institution is offering either an associate degree combined with on-campus short courses or a certificate program as well as contract education delivered to specific employers.

## MEETING INDUSTRY NEEDS THROUGH VOCATIONAL PROGRAMS FOR ENVIRONMENTAL TECHNICIANS

### Introduction

The final section of this report has three objectives. The first is to review the central findings of the study concerning current and anticipated employment needs for EHM technicians and related workers. The second is to summarize the major educational policy implications that have emerged from this research and to translate them into concrete goals for vocational education. The third is to identify specific educational program planning issues about EHM technicians that have surfaced from the study and to recommend ways to address them. To achieve these objectives, this discussion draws on specific findings from this research and on the results of other related studies.

### New Goals for Vocational Education and Their Application to the Environmental Industry

Education has always been charged with the responsibility of preparing individuals for the demands they will face when entering the work force. With social and economic factors increasing the skills required of workers in nearly every sector of the American occupational system, these workplace requirements have undergone a slow but steady evolution throughout this century. However, over the past two decades, these changes have been accelerated because new forces have emerged, transforming the nature of many jobs.

The most important of these forces have been (1) the explosive growth of modern technologies that have created new jobs and dramatically reshaped the content and requirements of some existing jobs; (2) the frequent shifts in product and service lines demanded by the marketplace that have created rapid changes in employers' skill requirements; and (3) the growing need for higher productivity throughout the U.S. work force, brought about by increased competition between American industry and lower wage foreign competitors. Faced with these trends, both employers and economic policy analysts have been demanding more highly skilled and flexible employees at various entry points in the occupational ladder. In some segments of the work force, such as the environmental industry, legislative and regulatory trends have also had a major impact by creating demand for entirely new jobs in a brand new industry.

This does not mean, however, that every occupation has experienced changing skill requirements or that every job will require a four-year college education in the future. In fact, by the year 2000, seventy percent of jobs in the United States will still require less than a college degree (Commission on the Skills of the American Workforce, 1990, p. 26). However, throughout the entire range of occupations, from jobs that typically require high school graduation to those demanding post-baccalaureate education, technical and nontechnical job requirements for beginning workers have increased and are expected to grow more in the future. These changes will demand some specialized postsecondary-level training and education for a great majority of workers, whether in the form of two-year associate degrees, certificate programs, or continuing education through short courses or other technical training.

Although demands for greater productivity have risen, the response of American industry has generally been inadequate. Throughout the 1980s, U.S. productivity growth was weak, especially in the burgeoning service sector of the economy (Johnston & Packer, 1987). The need for high productivity is especially acute in the environmental industry where the high costs of developing and implementing new technologies and of seemingly endless litigation make environmental cleanup a significant negative influence on short-term industry profitability.

To turn this situation around, employers have increasingly looked to educators for answers to the productivity problem or they have joined with educational institutions to seek a solution. The education community has responded by taking action at the local, state, and federal levels to define more clearly the skills required at various occupational entry points and to reshape curricula in secondary and postsecondary programs to meet these requirements. In turn, many vocational educators have taken this challenge a step further by reassessing and redefining the goals of vocational education.

## New Goals for Vocational Education

Traditionally, many individuals have expected the vocational education system to prepare students with the specific skills that match entry-level job requirements. However, in recent years there has been increased pressure on vocational educators to expand this mission. Demand for greater productivity; rapid expansion of the small business sector, which has limited resources to train its employees; and increasing needs for ongoing training and skill upgrading for employees in jobs undergoing significant technological change have all broadened the scope of vocational programs. As a result, vocational education has become responsible not only for the initial training of young people but also for educating adults who lack job skills and for reeducating employees to adapt to changing occupations.

This new mission has required vocational programs to identify strategies for preparing students for entry-level jobs as well as for multiple jobs that will require different and often higher level skills throughout their working lives. Students who have completed vocational programs must be ready to enter the world of work or to begin new careers with more than just entry-level job skills and the ability to read and write; they must also be able to succeed in a constantly shifting work force and economy.

## The Need for Nontechnical, Basic Technical, and Specific Industry-Related Skills

This rapidly changing and sometimes unpredictable employment picture has significantly affected the competencies upon which the objectives of vocational curricula are based as well as the content, structure, and pedagogic methods of vocational education. Today's vocational programs, especially those in technologically advanced fields such as environmental management, cannot prepare entry-level workers whose skills only match limited, technical entry-level job requirements. Of course, these workers must still have the technical skills that are required for the occupations and industries they will be entering. However, they must also have critical thinking skills that are essential for problem solving; effective written and verbal communication skills to be able to perform in more complex organizational settings; the ability to work as team members in environments that demand high productivity; and, most importantly, strong academic backgrounds that will enable them to learn on the job as performance requirements change or as they make career shifts.

### *Growing Demands on Environmental Management Programs*

Nowhere are these needs greater than in the environmental field, where an adequate supply of skilled personnel is critical to accomplishing the nation's environmental agenda by reducing pollution and cleaning up existing hazardous waste sites. The results of this study clearly indicate that environmental technician programs have experienced increasing demand from employers for highly skilled entry-level employees; for individuals who can rapidly assume the changing job responsibilities that arise from new technologies, changing legislation, and expanding regulation; and for employees who can work productively because their education and skills match industry's needs.

A wide range of experts from DOE facilities, private firms, and educational institutions who participated in this study concluded that current demand for technician-level personnel is often not met and that this demand is likely to increase in the future. These findings support several other studies that document the robust current employment market for environmental personnel and anticipated future growth in the environmental work force (Bay Area Council & Bay Area Bioscience Center, 1991; Busch, 1988; Cain, 1990; Ferrier, 1992; McNulty, 1991; Saltzman 1988). Moreover, the respondents from our study indicated that overqualified employees may be hired when appropriately educated employees are not available either in the labor market or within their organizations. High turnover among overqualified EHM technicians—and the higher wages they sometimes command—cannot help but reduce productivity in organizations that face this labor supply problem.

The study's findings also demonstrated that students in EHM programs need a strong foundation in both vocational and academic subjects. Specifically, with rapidly expanding knowledge and new technologies in the environmental field and with demands from federal agencies and the public to expedite environmental cleanup, students are required to master the traditional academic disciplines, especially in basic and more advanced sciences; to develop the technical skills, knowledge, and abilities necessary to perform exacting and strictly regulated duties; and to develop a high level of competence in written and verbal communications, critical thinking, and teamwork—all of which are essential to be effective in complex and highly technical environmental jobs.

Furthermore, the structure of jobs within the environmental industry is likely to undergo continuing change as a result of new technologies and the impact of economic trends. For example, the skyrocketing cost of waste disposal services is already creating a new demand for environmental personnel at all skill levels who will be responsible for implementing and managing waste reduction activities. With the costs of waste treatment as high as $200 to $350 per ton, industry has already determined that it pays to pursue alternatives to waste disposal (Finegan, 1988). As a result, environmental personnel must be armed with both the technical and nontechnical skills and knowledge that will enable them to shift and upgrade their jobs quickly to keep pace with marketplace demands—moving, perhaps, from waste disposal to waste reduction responsibilities.

Because environmental education programs are charged with preparing employees for an industry in which higher productivity will be critical to meeting the nation's environmental agenda, they are clearly facing greater demands from employers. Many of these programs are already strongly equipped to meet these industry requirements and at the same time to contribute to more effective education aimed at lifetime learning. For example, community college associate degree and certificate curricula programs have significant science requirements, and after completing these courses, students gain a firm grasp of scientific principles and the critical thinking skills underlying the scientific method.

In addition, community college environmental programs almost always rely on significant input from industry advisory boards; many of their instructors are practicing environmental professionals or have recently left such positions; and these programs are developing active partnerships with government agencies and firms that provide the work experience placements employers consider critical when hiring entry-level workers. Because of this solid education/industry interaction, environmental programs have an advantage over other vocational fields where industry has been less heavily involved.

Nonetheless, educational institutions have so far not entirely met the industry's challenge. Many of the community college respondents in our study indicated that they have increased enrollment targets over the past three years and are having little difficulty attracting students into these programs. Yet, employers continue to face shortages that often create lengthy job vacancies and sometimes propel managers to hire overqualified individuals. Without further enrollment increases, new technologies, expanding regulation, and growing public support for environmental cleanup, the shortage of technician-level personnel will likely worsen.

## Avoiding Future Labor Market Shortages: Expansion and Innovation in Environmental Education Programs

### New and Expanded Educational Programs and Approaches

There are several mechanisms through which expanded environmental programs can assume a significant long-term role in ensuring an adequate supply of personnel. Most obviously, developing more educational programs with higher enrollments for EHM technicians and related occupations will increase the pool of trained, entry-level employees. Larger enrollment capacities will also allow more employers to retrain their current employers for new or significantly altered environmental jobs.

However, other important channels exist for augmenting the supply of EHM technicians that do not require new programs or increased enrollment capacities. Many of these approaches may be just as important as program expansion for increasing the supply of EHM technicians and related workers because they can increase the total number of applicants, expand the volume of *successful* applicants, raise graduation rates, and reduce turnover among new employees.

#### *The Potential of Applied Academic Programs in Secondary Schools*

Applied academic programs at the secondary level that combine education in academic subjects with concrete work-related applications are one recent innovation that can increase the supply of environmental technicians in several ways. First, cognitive learning theorists argue that carefully developed and implemented applied academic programs can improve learning and increase students' active involvement in their education because they offer challenge and relevance to vocational students who may otherwise view school as not applicable to their future (Raizen, 1989). Consequently, expanding and developing new secondary-level environmental programs should increase the pool of employees for the environmental industry simply by increasing the supply of high school graduates who are motivated and prepared to pursue environmental careers in postsecondary institutions.

In addition, rigorous and challenging secondary-level environmental programs will increase the proportion of successful applicants who enter postsecondary environmental programs and will reduce dropout rates in these programs. Currently, dropout rates in community college programs are a troubling issue. Our survey of environmental educators indicated that dropout rates resulting from students' lack of fundamental math and science skills range from an average of twenty-eight percent in associate degree programs to almost thirty-three percent in certificate programs. The single most important reason why students fail to complete environmental programs is that they have inadequate backgrounds in math and science. As a result, by developing a cadre of students who successfully complete a high school environmental program, more applicants will be likely to meet academic entry standards and to complete postsecondary graduation requirements once enrolled.

### The Impact of Articulated Educational Programs

The expansion of coordinated (articulated) education programs is another way in which multilevel planning for environmental programs can increase the supply of environmental technicians without increasing enrollments. Recent efforts in California, Colorado, and Nevada are based on an excellent model—one in which community college and baccalaureate environmental programs are coordinated to facilitate continuing education for higher degrees and to foster upward occupational mobility by eliminating duplication of course requirements. In other fields such as health occupations, some of the most effective of these articulated programs have been based on fully coordinated planning that involves secondary/adult education, community colleges, and four-year postsecondary institutions. Environmental programs should be exploring these fully integrated models as well.

## Environmental Education Policy for the Future

Programs to integrate vocational and academic education or to expand articulated environmental curricula face several significant problems that require resolution if these efforts are to be successful. Similarly, the expansion of environmental education that is available in diverse formats—associate degree, certificate, and short courses programs—is challenged by shrinking higher education budgets and unnecessarily narrow views of the community college mission. This section concludes by describing the most important of these challenges.

### Delivering Environmental Education in Multiple Formats

While there is substantial agreement among employers about the skills that EHM technicians need, the circumstances of individual companies shape the types of environmental education that each employer requires. For example, some employers face massive retraining needs but already employ a work force that is well-educated and technically skilled. These firms have a strong need for short courses or other limited educational formats that can be used to upgrade the specific environmental management skills of an already sophisticated employee base. Other employers are new to environmental management or have a work force [illegible] little postsecondary educational experience. In these circumstances, managers seek both technical and nontechnical education that new hires or current employees can obtain in certificate and associate degree programs.

A challenge facing community colleges is to continue delivering quality environmental education in the diverse formats that employers need during the current period of funding retrenchment. On the one hand, it would be too easy for some institutions to focus unduly on short courses as a source of higher revenue while ignoring the fact that employers need workers with highly developed technical and nontechnical skills. Certificate and especially associate degree programs are well situated to deliver this combination of skills to potential new hires and current employees.

On the other hand, some institutions may fail to recognize both the important economic development function that short courses and contract education can provide and the continuing need of many employers for upgrade and refresher training that is most effectively delivered through noncredit formats. Unnecessary overemphasis on the academic and transfer functions of community colleges would be a disservice to the employer community that requires diverse types of environmental education.

### Integrating Vocational and Academic Education While Meeting the Entrance Requirements of Four-Year Institutions

Results of this study highlight employers' need for technicians with high levels of technical and nontechnical skills. To improve students' skill development in these areas and to help resolve both current and future personnel shortages, we have argued for integrating vocational and academic education in environmental education programs. However, at the secondary and postsecondary levels, these curriculum reform efforts may conflict with the need for students to meet requirements for entry or transfer into four-year institutions. Specifically, if applied academic courses do not fulfill these entrance or transfer requirements, then such programs may achieve one set of objectives—reducing dropout rates and enhancing entry-level work skills—while at the same time failing to meet the equally important objective of enhancing students' opportunities for occupational mobility through additional education.

Thus, it is vital to address the issue of how applied secondary and postsecondary academic programs can also meet the entrance and transfer requirements of four-year institutions. Resolving this issue will require coordinated planning and education policies that fully involve key participants from secondary schools, community colleges, and four-year postsecondary institutions.

### Industry and Education Partnerships

Active partnerships between industry and education have become the hallmark of many vocational programs that provide students with rigorous preparation for advanced technology occupations. Results of this study highlight both the need and the effectiveness of these partnerships in the environmental field. For example, managers at DOE facilities and in private industry who participated in study interviews stressed the importance of on-the-job work experience as a significant hiring criterion for new employees.

Similarly, survey responses from many of these managers indicated that some specific industry-related skills—and even some nontechnical skills such as teamwork—are best learned on the job. Particularly in areas such as maintaining protection, field sampling techniques, and hazardous waste handling and labeling, experience performing these actual job requirements is a critical element in developing important job skills. Given the need for students to have directly applicable work experience, it is important that EHM technician programs offer students opportunities to work in environmental jobs as part of their college curricula.

Community colleges in many areas of the country have included work experience components in their environmental curricula by establishing strong working relationships with local industry and government agencies. In addition, employers from environmental firms have supported environmental education by serving on advisory boards, donating equipment, and collaborating in regional organizations such as the PETE (Partnership for Environmental Technology Education). All of these efforts have benefited the growing number of community college environmental programs.

However, these partnership efforts must be expanded at both the local and regional levels. Educators who participated in this study emphasized that environmental technician programs require expensive equipment with substantial ongoing maintenance costs. They also revealed continuing difficulties recruiting faculty.

Our survey of educators indicated that forty-four percent of responding institutions found it "very difficult" or "somewhat difficult" to recruit instructors for the 1991-1992 academic year. This figure is down from forty-eight percent in 1990-1991 and fifty percent in 1989-1990 and might reflect increased knowledge of community college environmental programs by technically competent professionals or a growing commitment by employers to support community colleges. Nonetheless, it still indicates that these community college programs need assistance from industry in filling faculty positions.

Local partnerships between colleges and environmental firms can provide an avenue for institutions to communicate their faculty needs and for firms and public agencies to respond by encouraging employees to teach. They can even offer release time from work for some employees to teach at local community colleges. Moreover, industry support of community college programs can proceed through the development of regional partnerships. These groups can serve as a source of funding to upgrade teachers' salaries in fields where instructors are hard to find by offering these instructors part-time and summer employment. They may also support colleges by helping them purchase and maintain expensive but needed equipment. Finally, regional partnerships can function as the locus of periodic labor market studies that promote new program implementation or ongoing program modifications.

**Environmental Training Versus Retraining**

The need for retraining and lifelong learning skills to meet the advanced technology requirements of the 1990s and beyond has become almost a mantra in economic and educational circles. This study clearly demonstrates that environmental education has already become part of this retraining of America's work force. In general, students are not matriculating into environmental programs immediately after high school nor are new high school graduates enrolling in environmental short courses. Relatively few students in EHM technician programs are under twenty-five years old, and a substantial majority of students are pursuing environmental courses either because they are explicitly planning to change careers or because their employers are paying for their retraining.

The magnitude of the environmental cleanup and restoration problem over the next thirty to fifty years will be substantial, requiring the infusion of substantial economic and human resources. At the same time, cohorts of entry-level workers will continue to be small. In addition, until substantial progress is made in improving the math and science capabilities of high school students, inadequate numbers of high school graduates will be prepared for the rigorous requirements of community college environmental programs. This scenario is one that argues forcefully for viewing postsecondary environmental programs as an excellent arena for retaining working adults who have the maturity and math and science backgrounds necessary to be effective environmental technicians.

# SUMMARY AND CONCLUSIONS

This study explores labor market trends, educational needs, and skill requirements for environmental hazardous materials technicians based on interviews, focus groups, and survey data. We focus specifically on the needs of private-sector employers and the U.S. Department of Energy (DOE). This latter emphasis on DOE needs reflects the tremendous environmental challenge that faces this agency and DOE's partial sponsorship of the study.

Study results are based on data gathered in two stages. First, the researchers interviewed 144 experts in the environmental management field, including employers and educators of EHM personnel. We used these interviews to create a foundation of hypotheses about trends in the environmental industry and to generate a preliminary list of the skills, knowledge, and abilities that employers require of entry-level technicians and related personnel. From the results of these interviews, we developed a mail survey that was distributed to much larger samples of employers and educators of EHM technicians. These samples included representatives of organizations and educational institutions throughout the United States. The sample populations for both the interviews and the survey mailing included employers of EHM personnel from private industry and DOE facilities and educators primarily representing community colleges.

## Summary of Findings

The findings from this study can be grouped into three broad categories: trends in employment needs for EHM technicians and related workers, educational implications resulting from these expected trends in employment, and issues related to program planning for EHM technician training. These issues are summarized below.

### Industry Trends and Needs

American educators are responsible for adequately preparing and training our nation's work force. As our economy and industries continue to experience rapid change resulting from internal and external forces, educators must implement parallel adjustments in programs and curricula to address new levels of demand for personnel and new skill requirements. Educators must continually conduct research into industries' employment needs and analyze the job market to predict fluctuations in levels of hiring. This study discusses the relevant educational issues related to employment trends and educational needs in the environmental management industry.

The majority of experts surveyed and interviewed during this study concluded that an adequate supply of trained technician-level personnel in the environmental management industry is not readily available. These same individuals expect that demand for such personnel will increase moderately to substantially in the near future. For example, seventy-seven percent of the 128 supervisors and managers responding to this study indicated that they will need to hire additional EHM technicians in the next one to three years. Both DOE and private-sector managers emphasized the inadequacy of current labor pools and the potential for future employment growth.

In order to overcome this shortfall, some managers have been forced to hire overqualified applicants or spend considerable amounts of money and time training underqualified individuals to perform required tasks. Our interviews and focus groups revealed that one consequence of hiring overqualified individuals is high turnover in technician-level jobs. With the costs of environmental cleanup and management rising to ever higher levels; increasing local, state, and federal mandates requiring industry to meet environmental standards; and the near universal call for a more productive American work force—it is crucial that industry find more cost-effective alternatives for recruiting appropriately trained environmental personnel.

The majority of industry representatives who anticipated recruiting additional EHM personnel indicated that the most desirable education for technicians is some type of community college-level preparation. Unfortunately, these same managers and supervisors were frequently unable to find sufficient numbers of applicants with this background. As a result, many industry representatives promote expanding vocational programs at community colleges, either degree or nondegree, to provide a more adequate pool of trained technician-level personnel.

Our study demonstrates that the skills required of technician-level environmental personnel are remarkably consistent across a broad range of specific occupations in both DOE and private-sector employment. There are three general skill areas that employers require of their entry-level technicians. Most importantly, managers and supervisors acknowledge a need for applicants to be well-trained in fundamental nontechnical skills that can be applied to many employment activities. These include verbal and written communication, problem solving, ability to read and comprehend technical material, teamwork, and time management. Employers also acknowledge a core set of academic competencies that technicians must master. These academic competencies include basic levels of high school and college science and high school math, including algebra and trigonometry.

Courses in these areas provide technicians with the technical background to understand the dynamics of the hazardous materials that they work with. To a somewhat lesser extent, employers desire their technicians to have knowledge of specific industry-related tasks and responsibilities. Most important among these are record keeping requirements; maintaining personal and area protection; knowledge of OSHA, CERCLA, and RCRA regulations; and hazardous materials and waste handling. Not surprisingly, employers are more willing to provide specific technical programs for their employees—through on-the job training or contracted short courses—but they look to educational institutions to provide basic nontechnical skills and fundamental academic competencies.

In general, educational administrators and instructors that were surveyed confirmed the conclusions about necessary skills and desired educational programs for technicians that resulted from our survey of employers. Many educational institutions have assessed the local demand for EHM personnel and have responded by implementing new or expanded vocational training programs. Educators who have developed EHM programs at their schools have placed a very strong emphasis on virtually all the skills and knowledge that were recognized as important by employers of technician-level personnel. Consequently, where programs exist, there is a very good fit between the types of education received by environmental personnel and the skill requirements of industry. In some cases, this fit is not surprising because DOE personnel have been heavily involved in shaping environmental programs at local community colleges. However, this is also true in locations where colleges are serving a more diverse local base of employers.

### Educational Implications

New program development and increased enrollment capacity would help bridge the gap between industry demand and educational supply for EHM technicians. The results of our research suggest that the most desirable level of educational attainment needed to convey the necessary aptitudes and competencies for EHM technicians is offered at the community college level, whether through a formal degree program or individual short courses. We strongly recommend that community colleges throughout the nation assess the demand for environmental personnel in their region or community. Based on results of these assessments for local labor markets, we suggest that two-year institutions develop programs to meet these needs. The consistency of skill requirements across technician-level jobs suggests that most EHM programs can share a core of courses that focuses on basic technical and nontechnical competencies. However, local industry needs must be addressed also by providing additional courses tailored to the local labor market.

To meet the projected need for additional technician-level environmental personnel, we recommend the development of additional programs and the expansion of enrollment capacity at postsecondary institutions. We also suggest that community colleges establish links with secondary vocational education curricula in order to increase the number of high school students that will successfully pursue postsecondary environmental programs. Because of the need for a more technically trained applicant pool across all industries, articulation programs between secondary schools and postsecondary vocational programs have moved to the forefront of the national educational agenda. Applied academic programs at the secondary level can increase students' abilities to transfer their knowledge to a clear vocational goal after graduation. A solid foundation of math, science, and communications courses provided at the secondary level will prepare students for a variety of technical vocational programs at the postsecondary level, including environmental hazardous material management.

Our study revealed that a lack of fundamental math and science skills is the most frequent reason why students in environmental technician associate degree and certificate programs fail to complete their educations. Educators estimate that twenty-eight percent of associate degree students and thirty-two percent of those in certificate programs drop out because they lack these important tools for academic success. Adequate preparation at the secondary level will reduce this obstacle and improve program graduation rates. As a result, the integration of secondary-level vocational education with two-year postsecondary environmental curricula is an excellent strategy for preparing a qualified cadre of personnel to meet the current and expected employment needs of the EHM industry.

## Program Planning

Our findings clearly indicate that no single training or education program will be suitable to all employers of EHM personnel. In some instances, employers already have a relatively sophisticated and educated pool of employees who need only limited retraining to perform in environmental management jobs. Many of these organizations employ baccalaureate-level personnel with backgrounds in fields other than environmental management. In these cases, short courses that focus on laws regulating hazardous materials used on the job and other specific technical areas are probably most appropriate. In other cases, employers are looking to the outside labor market as a source of individuals to perform more general technical support functions related to the management of hazardous materials. The most desirable type of educational attainment for these employees is achieved through a comprehensive and integrated vocational and academic program such as an associate degree or certificate.

In order to determine what programs or courses are most suitable for each community college, it is crucial that industry and education partnerships be established to communicate the needs of both entities. Through these relationships, educational administrators may target the needs of employers; industry officials can help establish competencies and curricula; cooperative use of facilities and equipment can be arranged; and cost-effective education and employment programs can be developed.

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# APPENDIX A

## Site Visits for Intensive Interviews

### Department of Energy Facilities

- Fernald Site
- Hanford Reservation
- Idaho National Engineering Laboratory
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Nevada Operations Office and Nevada Test Site
- Oak Ridge Site (Oak Ridge National Laboratory, Y12 Plant, K25 Site)
- Pantex Plant
- Rocky Flats Plant
- Sandia National Laboratory at Livermore
- Savannah River Site

### Private Industry Representatives

- IFC Kaiser Engineers, San Francisco, CA
- Dow Chemical, Pittsburg, CA
- OHM Corporation, Sacramento, CA
- Excel Technologies, Fremont, CA
- Chemical Waste Management, Fremont, CA
- The Mark Group, Walnut Creek, CA
- Aqua Terra Technologies, Walnut Creek, CA
- Chevron Research and Technology Company, Richmond, CA
- Bechtel Corporation, San Francisco, CA
- H & H Environmental Services, San Francisco, CA

# APPENDIX B

Respondent's Name ____________________

## Occupational Skills Assessment

### Job Analysis Interview Protocol

### EHM Technicians Study

***Job Supervisor Form***

Interviewer Name ____________________ Date ____________________
Position ____________________
Respondent Name ____________________ Title ____________________
Organization Name ____________________ Telephone ____________________

**I. Background. Use informal questions to determine the following:**

1. What is this respondent's job? What is the job title?

2a. How does this respondent know about the EHM tech job? [Is he/she a former job incumbent or a supervisor who has never performed this job?]

2b. [If relevant, ask, How long did this respondent perform the EHM job? How recent was this activity? (e.g., current, within the past one to three years, more than three years ago?)

2c. Does this individual also supervise craft workers who handle hazardous materials?

**II. Skills Assessment Questions**

***Ask the following*:**

3a. Do you supervise more than one type of EHM technician? How many? If yes, what are their job titles and duties, and how do their responsibilities differ?

#1

#2

#3

_______________________________

Respondent's Name

3b. At the present time, how many technicians are in each of these categories and working under your supervision? Has this number been increasing or decreasing, or has it remained the same? What do you expect will happen to this number of technicians in the next one to three years?

[***Interviewer Note*: *Pick one of the larger technician categories listed above and ask all of the following questions about individuals in this category. In the course of this set of interviews at this site, try to obtain listings for all technician categories.***]

***Ask the following while showing the respondent the task list form*:**

3c. Now I'd like to turn to the specific questions about [__________ technicians] that will take up the rest of the interview. As we go through the interview, I'd like you to think about the ways that an entry-level person would perform this technician job *today*. As we move through these questions, I will be attempting to determine the major job tasks that are performed; the equipment that is used in this job; and what abilities, skills, or knowledge an individual needs to have to adequately perform these tasks at the entry level.

***Interviewer Note*: *These are definitions that might be useful if the respondent asks about the meaning of skills, knowledge, and abilities.***

**Skills**: suggest proficiency in an applied activity, may be physical, but may also apply in a mental or physical sense (e.g., legible handwriting, time management skills, or skill in the use of visual aids).

**Knowledge**: a specific set of information gained from an academic discipline, from procedural manuals, or from experience (e.g., knowledge of company policy, knowledge of how to use a software program).

**Abilities:** broad human characteristics that result from either native talent or from a variety of experiences over time (e.g., writing ability, mechanical aptitude, manual dexterity).

______________________________
Respondent's Name

4. Would you now spend a few minutes telling me what are the *typical* major tasks that someone would perform in this entry-level job on a *typical* day. After you give me a list of major tasks, I will return to the list and ask you about the kinds of equipment that are used and the abilities, skills, and knowledge that are required to perform each major task. [***Ask the respondent to go through a list of the major tasks performed in the job and record them on the attached sheet.***]

5. Now, let's return to the list of job tasks that you have just given me and for each one please tell me about any tools or equipment that are used to perform this task. [***Record this information on the attached sheet.***]

6. Next, I want to focus more specifically on the abilities, skills, and job knowledge required to perform this job at the entry level. Could you please tell me what the types of knowledge, abilities, and skills are necessary for each of the tasks in this job. Let's begin by taking these job tasks one at a time, and don't be concerned about identifying each one separately as a knowledge, skill, or ability—just lump these all together. [***Return to the job task list and record information on skills, knowledge, and abilities.***]

7. With all of this background about job duties, skills, knowledge, and abilities in mind, please tell me the following:
   a. On the whole, do entry-level employees that you recently have interviewed for this job generally have the skills, knowledge, and abilities that you consider important to perform the job?

      _____ Yes　　　　_____ No
   b. If no, what skills are usually lacking, and how do you make up for these skill deficiencies?

8. Please think about the one or two employees you have known who have performed exceptionally well in this job. What particular skills have made them exceptional performers? What were their backgrounds in terms of work experience and training?

______________________________
Respondent's Name

9. When you hire entry-level employees for this job, what are their typical backgrounds, (e.g., previous work experience, schooling, specialized training)? From what sources do you recruit these individuals? What are the best recruitment sources?

10. What do you think is the best way for individuals to obtain the skills that are necessary to work as an EHM technician? [***Probe for information about high school, postsecondary, on-the-job training, and apprenticeship programs***]. Would individuals who have a two-year technical degree in hazardous materials technology meet your staffing needs?

11. Do you think that a single EHM training program could provide the basic foundation for entry-level workers in all hazmat job categories? If not, what special programs should exist for individual types of technicians?

12. What do you view as the training and education needs for crafts workers who are responsible for handling hazardous materials?

***Thank you very much for taking the time to talk with me about this job and for helping us with this project.***

________________________
Respondent's Name

# Occupational Skills Assessment

## Job Analysis Interview Protocol

*EHM Technician Job Incumbent Form*

Interviewer Name ____________________ Date ______________
Position ____________________________________________
Respondent Name ______________ Title ____________________
Organization Name ______________ Telephone __________________

## I. Background

[*Use informal questions to determine the following*:]

1. What is the job that this individual now performs? What is the job title?

2a. How does this respondent know about this job? [Is he/she a current job incumbent or a former incumbent of this job?]

2b. How long has (did) this respondent performed this job? How recent was this activity if it was in the past? (e.g., current, within the past one to three years, more than three years ago?) What kind of work did the respondent do before beginning this job?

## II. Skills Assessment Questions

***Ask the following*:**

3. Now I'd like to turn to the specific questions about this job that will take up the rest of time we'll spend on the interview. [***Show respondent the task list form***]. As we go through the interview, I'd like you to think about the way that [**you or an entry-level person**] would perform this job on a typical day. As we move through your description of a typical day on the job, I'll be developing a list of the major job tasks that are performed; the equipment that is used in this job; and what abilities, skills or knowledge you or someone else would need to perform these tasks as an entry-level employee. [***If respondent has been in this job for a long time, emphasize that we are interested in entry-level job responsibilities.***]

____________________________
Respondent's Name

***Interviewer Note*: *These are definitions that might be useful if the respondent asks about the meaning of skills, knowledge, and abilities.***

**Skills**: suggest proficiency in an applied activity, may be physical, but, may also apply in a mental or physical sense (e.g., legible handwriting, time management skills, or skill in the use of visual aids).

**Knowledge**: a specific set of information gained from an academic discipline, from procedural manuals, or from experience (e.g., knowledge of company policy or knowledge of how to use a software program).

**Abilities:** broad human characteristics that result from either native talent or from a variety of experiences over time (e.g., writing ability, mechanical aptitude, manual dexterity).

4. Now I'd like us to spend a few minutes with you telling me about the *typical* major tasks that an entry-level employee would perform in this job on a *typical* day. After you give me a complete list of these major tasks, I will return to the beginning of the list and ask you about the kinds of equipment that are used and the abilities, skills, and knowledge that are required to perform each major task.
   [***Ask the respondent to go through a list of the major tasks performed in the job and record them on the attached task list sheet.***]

5. Now, let's return to the list of job tasks that you have just given me. For each task, please tell me about any tools or equipment that are used to perform this task. [***Record this information on the attached sheet.***]

6. Next I want to focus more specifically on the abilities, skills, and job knowledge required to perform this job at the entry level. Could you please tell me what are the types of knowledge, abilities, and skills necessary for each of the tasks in this job. Let's begin by taking these job tasks one at a time, and don't be concerned about identifying each one separately as a knowledge, skill, or ability—just lump these all together. [***Return to the job task list and record information on skills, knowledge, and abilities.***]

______________________________
Respondent's Name

7. What is your educational background, and where did you receive your training as an EHM technician?

8. Finally, is there anything else you would like to tell me about the skills or knowledge that are important for someone to perform this job as an entry-level employee?

***Thank you very much for taking the time to talk with***
***me about your job and for helping***
***us with this project.***

***Record any additional comments or information here*:**

# APPENDIX C

# Occupational Skills Assessment

## Job Analysis Interview Protocol

*Private Industry Sample*
*Manager's Interview*

Interviewee's Name ______________________ Date ______________

Job Title ______________________ Organization ______________

Interviewer's Name ______________________

**A. Begin Interview by Describing Study Objectives, Sponsorship, and Methods.**

**B. Next, Provide the Definition of EHM Technician/Worker That We Are Using in the Study.**

**BACKGROUND**

1. Please briefly describe the area and activities for which you have management responsibility.

2. What types of personnel work under your overall management?

   managers/professionals:

   technicians:

   operatives:

3. Please briefly describe the activities for which EHM technicians and related workers such as operatives are responsible in your area (i.e., what jobs do these individuals perform?).

Job Title #1 ______________________

Job Title #2 ______________________

Job Title #3 ______________________

Job Title #4 ______________________

## RECRUITMENT AND LABOR MARKET ISSUES

5. How many EHM technicians and related workers typically are employed on your project or in your department?

6. Over the past year or two, how easy or difficult has it been for you to recruit and hire EHM technicians and related workers into your organization? If it has been difficult, why do you think this is the case? Does this situation apply to all categories of EHM technicians and workers? Which ones?

7. How qualified have applicants been for your open positions? If they have lacked qualifications, what have been their deficiencies? What have been their strengths? Please answer this question in reference to each category of EHM technician and related worker with which you are familiar.

8. Over the past year, how many openings have there been for each type of EHM technician in your organization? Do you expect that openings for these positions will increase or decrease in the next year or two? Why?

## OCCUPATION'S SKILL REQUIREMENTS

### Communication Skills:

9. How important are written and verbal communication skills for effective job performance in your department? Have applicants for open positions in your organization been lacking in communications skills?

### Teamwork Skills:

10. How important are teamwork skills for effective job performance in your organization? Have recently hired entry-level employees in your department been lacking in teamwork skills?

### Technical Knowledge:

11. What are the three most important areas of technical knowledge for EHM technicians and workers employed by your organization?

12. What are your best sources of applicants for open positions as EHM technicians and related workers?

## APPENDIX D

## EHM Technician Skills, Knowledge, and Abilities

---

### Nontechnical Skills

Written Communication
Lifting Heavy Objects
Comprehension of Technical Material
Time Management
Verbal Communication
Problem Solving
Teamwork

### General Technical Skills

High School-Level Chemistry
Introductory-Level Geology
High School-Level Physics
Toxicology
Basic College-Level Chemistry
High School-Level Math
Basic College-Level Physics

### Industry-Specific Skills

Calibrating Detection and Survey Instruments
Constructing and Installing Gas Monitoring Wells
Hazardous Waste Handling
Conducting Helium Leak Testing
Taking Industrial Hygiene Measurements
Maintaining the Integrity of a Closed System
Maintaining Personal and Area Protection
Record Keeping
Responding to Radioactive Releases
Pumping Hazardous Materials
Monitoring Storage Facilities and Containers
Protocols for Handling Radioactive Wastes
Protocols on Hauling Waste Drums Safely
EPA Regulations, Including CERCLA and RCRA
OSHA Hazardous Waste Regulations
Forklifts
Generators
Maps
Penetrometer
Land Survey Equipment
Site Evacuation
First Aid
Hazardous Waste Labeling
Maintaining Chain of Custody
Creating Maps from Photos
Packing Wastes
Reading Gauges
Responding to Chemical Spills
Sampling Hazardous Materials
Sampling Water and/or Sludge
Measuring Specific Gravity
Audio-Visual Equipment
Calibration Equipment
Cement Mixers
Earthmoving Equipment
Gas Chronometer
Large Vehicles
Monitoring Equipment
Radiation Detection Equipment
Volt Meter

# APPENDIX E

# ENVIRONMENTAL HAZARDOUS MATERIALS (EHM) TECHNICIAN SKILLS QUESTIONNAIRE

**Please complete this form for individuals in the job title listed below.**

The following is a list of the skills and knowledge that employees in various EHM positions may need in order to perform their jobs. For each skill or knowledge, please **indicate** how important it is for an employee to perform this job effectively. Also, **circle** whether this skill or knowledge is best learned on the job, in a short course, in a two-year college academic program, or in a four-year degree program.

Job title ______________________________

| | How important is this knowledge, skill, or ability? | | | | How is this knowledge or skill best learned? (Leave blank if it is not at all important.) | | | |
|---|---|---|---|---|---|---|---|---|
| | Not at all Important | Somewhat Important | Very Important | Critically Important | On the Job | In an On-Site Short Course | At a Two-Year College | In a Four-Year College Program |
| **Basic technical skills, knowledge, and abilities** | | | | | | | | |
| 1. High school chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 2. Basic college chemistry | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 3. Introductory-level geology | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 4. High school-level math (algebra, geometry, basic statistics, metrics) | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 5. High school physics | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 6. Basic college physics | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 7. Toxicology | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **Basic nontechnical skills, knowledge, and abilities** | | | | | | | | |
| 8. Written communications | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 9. Verbal communications | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 10. Lifting of heavy objects | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

EHM Technician Survey

Job title ______________________________

| | How important is this knowledge, skill, or ability? | | | | How is this knowledge or skill best learned? (Leave blank if it is not at all important.) | | | |
|---|---|---|---|---|---|---|---|---|
| | Not at all Important | Somewhat Important | Very Important | Critically Important | On the Job | In an On-Site Short Course | At a Two-Year College | In a Four-Year College Program |
| 11. Problem solving | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 12. Comprehension of technical written material & instructions | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 13. Teamwork | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 14. Time management | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **Knowledge of and ability to follow standard operating procedures for . . .** | | | | | | | | |
| 15. Calibrating detection and survey instruments | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 16. Constructing and installing soil gas monitoring wells | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 17. Site evacuation | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 18. First aid | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 19. Hazardous waste handling | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 20. Hazardous waste labeling | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 21. Conducting helium leak testing | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 22. Taking industrial hygiene measurements | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 23. Maintaining chain of custody | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 24. Maintaining the integrity of a closed system | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

EHM Technician Survey

Job title ____________________

|  | How important is this knowledge, skill, or ability? |  |  |  | How is this knowledge or skill best learned? (Leave blank if it is not at all important.) |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Not at all Important | Somewhat Important | Very Important | Critically Important | On the Job | In an On-Site Short Course | At a Two-Year College | In a Four-Year College Program |
| **Knowledge of and ability to follow standard operating procedures for . . .** |  |  |  |  |  |  |  |  |
| 25. Creating maps from photos | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 26. Packing waste | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 27. Maintaining personal and area protection | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 28. Reading gauges | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 29. Record keeping | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 30. Responding to chemical spills | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 31. Responding to radioactive materials release | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 32. Sampling hazardous materials | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 33. Pumping hazardous materials | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 34. Sampling water and/or sludge | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 35. Measuring specific gravity | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 36. Monitoring storage facilities and containers | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **Knowledge and ability to follow requirements of . . .** |  |  |  |  |  |  |  |  |
| 37. DOE protocols for handling radioactive waste and materials | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 38. DOE protocols on hauling drums safely | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

Job title ________________________________

| | **How important is this knowledge, skill, or ability?** | | | | **How is this knowledge or skill best learned? (Leave blank if it is not at all important.)** | | | |
|---|---|---|---|---|---|---|---|---|
| | Not at all Important | Somewhat Important | Very Important | Critically Important | On the Job | In an On-Site Short Course | At a Two-Year College | In a Four-Year College Program |
| 39. EPA regulations, including CERCLA and RCRA | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 40. OSHA hazardous waste operations regulations | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| **Demonstrated ability to use or operate . . .** | | | | | | | | |
| 41. Audio-visual equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 42. Calibration equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 43. Cement mixers | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 44. Earthmoving equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 45. Forklifts | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 46. Gas chronometer | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 47. Generators | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 48. Large vehicles | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 49. Maps | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 50. Monitoring equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 51. Penetrometer | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 52. Radiation detection equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 53. Land survey equipment | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 54. Volt meter | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

EHM Technician Survey

Job title ______________________________

|  | How important is this knowledge, skill, or ability? |  |  |  | How is this knowledge or skill best learned? (Leave blank if it is not at all important.) |  |  |  |
|---|---|---|---|---|---|---|---|---|
|  | Not at all Important | Somewhat Important | Very Important | Critically Important | On the Job | In an On-Site Short Course | At a Two-Year College | In a Four-Year College Program |
| **Other important skills, knowledge, or abilities** |  |  |  |  |  |  |  |  |
| 55. ____________________ | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 56. ____________________ | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 57. ____________________ | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 58. ____________________ | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 59. ____________________ | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |

## GENERAL QUESTIONS ABOUT THIS JOB

### Education

60. Put an **X** next to the description that represents the most frequent education/training level of individuals performing this job at your facility.
_____ completed an apprenticeship _____ high school or less _____ high school plus limited on-site training ____ high school plus extensive on-site training
_____ high school plus coursework at a two-year college _____ a two-year college degree _____ a four-year college degree

61. Put an **X** next to the answer that best describes the level of education/training that **you believe** is necessary for this job.
_____ an apprenticeship _____ high school only _____ high school plus limited on-site training _____ high school plus extensive on-site training
_____ high school plus coursework at a two-year college _____ a two-year college degree in an environmental hazardous materials field
_____ a four-year college degree

### Recruitment

62. Please indicate whether you use any of the following recruitment sources for individuals in this job classification. **(Check all categories that apply.)**
_____ former military personnel
_____ employees in other jobs already working on site
_____ local junior colleges
_____ local high schools
_____ contractor personnel working on other environmental projects
_____ other ________________________________________

63. Which source provides the largest number of new employees for this job classification? ____________________________

64. Among these recruitment sources, which has provided you with the best qualified employees to work in this job category? ______________________________

65. Over the past year, how difficult has it been for you to recruit **qualified individuals** to fill openings for this position?
______ easy ______ difficult
______ slightly difficult ______ virtually impossible

66. Are there some individuals working in this job category who have more education than you believe is necessary to perform this job because recruitment at the appropriate educational level is difficult? _______ yes _______ no

67. If yes, how often does this occur? _______ seldom _______ regularly _______ often _______ very often

**Future Demand**

68. Do you anticipate that you will need to hire additional numbers of employees into this job classification in the next one to three years? ______ no ______ yes

69. If yes, how many additional employees will you need . . .
______ to replace employees that move into other positions or leave the organization?
______ to fill new positions created to perform work that is now in process?
______ to fill new positions that are likely to be created to accomplish new activities?
What are these anticipated new activities? ______________________________

Please complete the following information:

Your Name ______________________ Your Department ______________________ Your Job Title ______________________

**Thank you for taking the time to complete this questionnaire. Please return it in the enclosed envelope to**

**MPR Associates, Inc.**
**1995 University Avenue, Suite 225**
**Berkeley, CA 94704**

# APPENDIX F

## Employer Rankings of SKAs by Employer Type

| Skills, Knowledge, & Abilities (SKAs) | Rank Order<br>All Employers | <br>DOE Employers | <br>Private Employers |
|---|---|---|---|
| Record Keeping | 1 | 1 | 1 |
| Comprehension of Technical Material | 2 | 2 | 4 |
| Teamwork | 3 | 3 | 3 |
| Verbal Communications | 4 | 5 | 2 |
| Maintaining Personal & Area Protection | 5 | 4 | 9 |
| Written Communications | 6 | 9 | 5 |
| OSHA Hazardous Waste Regulations | 7 | 10 | 6 |
| Hazardous Waste Handling | 8 | 8 | 10 |
| Hazardous Waste Labeling | 9 | 7 | 12 |
| Responding to Chemical Spills | 10 | 6 | 15 |
| Problem Solving | 11 | 15 | 8 |
| EPA Regulations, including CERCLA & RCRA | 12 | 11 | 16 |
| Time Management | 13 | 18 | 11 |
| Maintaining Chain of Custody | 14 | 16 | 14 |
| Sampling Hazardous Materials | 15 | 25 | 7 |
| High School Level Math | 16 | 13 | 19 |
| Reading Gauges | 17 | 17 | 17 |
| Protocols on Hauling Waste Drums Safely | 18 | 19 | 21 |
| Monitoring Equipment | 19 | 21 | 18 |
| First Aid | 20 | 20 | 20 |
| Sampling Water and/or Sludge | 21 | 32 | 13 |
| High School Level Chemistry | 22 | 23 | 25 |
| Monitoring Storage Facilities & Containers | 23 | 27 | 23 |
| Packing Wastes | 24 | 26 | 27 |
| Site Evacuation | 25 | 24 | 28 |
| Protocols for Handling Radioactive Wastes | 26 | 12 | 35 |
| Calibrating Detection & Survey Instruments | 27 | 28 | 22 |
| Responding to Radioactive Releases | 28 | 14 | 36 |
| Calibration Equipment | 29 | 33 | 24 |
| Maintaining the Integrity of a Closed System | 30 | 31 | 29 |
| Pumping Hazardous Materials | 31 | 34 | 26 |
| Radiation Detection Equipment | 32 | 22 | 38 |
| Toxicology | 33 | 29 | 32 |
| Lifting Heavy Objects | 34 | 30 | 34 |
| Basic College Chemistry | 35 | 35 | 30 |
| Taking Industrial Hygiene Measurements | 36 | 37 | 33 |
| Maps | 37 | 38 | 31 |
| High School Physics | 38 | 36 | 43 |
| Forklifts | 39 | 39 | 39 |
| Measuring Gravity | 40 | 40 | 44 |
| Basic College Physics | 41 | 41 | 46 |
| Introductory Geology | 42 | 45 | 40 |
| Constructing & Installing Gas Monitoring Wells | 43 | 50 | 37 |
| Generators | 44 | 43 | 45 |
| Gas Chronometer | 45 | 48 | 42 |
| Large Vehicles | 46 | 49 | 41 |
| Volt Meter | 47 | 42 | 49 |
| Penetrometer | 48 | 46 | 47 |
| Audio-Visual Equipment | 49 | 44 | 50 |
| Land Survey Equipment | 50 | 52 | 48 |
| Creating Maps from Photos | 51 | 47 | 51 |
| Conduct Helium Leak Testing | 52 | 51 | 54 |
| Earthmoving Equipment | 53 | 54 | 52 |
| Cement Mixers | 54 | 53 | 53 |

☐ =Upper Quartile
▒ =Middle 50%
▓ =Lower Quartile

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# APPENDIX G

# ASSESSMENT OF LABOR MARKET AND EDUCATIONAL NEEDS FOR HAZARDOUS MATERIALS TECHNICIANS AND RELATED WORKERS

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION
AND THE UNITED STATES DEPARTMENT OF ENERGY

## I. PROGRAM BACKGROUND

1. Which of the following types of environmental hazardous materials programs are offered by your college? *(Check all that apply.)*

**Program type**

- ☐ Baccalaureate degree
- ☐ Two-year associate degree
- ☐ Two-year certificate
- ☐ One-year certificate
- ☐ Individual semester (or quarter) length courses that are not part of degree or certificate programs
- ☐ On-campus short courses open to the general public
- ☐ On-campus or off-campus short courses offered on a contract basis to employees of a single organization
- ☐ Other *(specify)* ____________________

2. During the 1991-1992 academic year, what was your total enrollment in each of the following types of environmental hazardous materials programs? *(Please provide FTE enrollment, if possible; otherwise, give headcount; leave blank if not applicable.)*

| 1991-1992 Enrollment | | |
|---|---|---|
| **FTE** | **Headcount** | |
| | | Baccalaureate degree |
| | | Two-year associate degree |
| | | Two-year certificate |
| | | One-year certificate |
| | | Individual semester (or quarter) length courses that are not part of degree or certificate programs |
| | | On-campus short courses open to the general public |
| | | On-campus or off-campus short courses offered on a contract basis to employees of a single organization |
| | | Other *(specify)* ____________________ |

3. In what year did your college first begin offering degree and/or certificate programs in environmental hazardous materials? *(Leave blank if not applicable.)*

**Year first offered**

19____ Baccalaureate degree(s)
19____ Associate degree(s)
19____ Certificate(s)

4. How many postsecondary institutions in your state offer environmental programs? *(Please provide your best estimate if you do not know the exact number.)*

**Number of institutions**

________ Offer baccalaureate degrees
________ Offer associate degrees
________ Offer certificates

5. Using FTE counts, how many faculty members, administrators, and support staff were employed in your environmental hazardous materials program last year (1990-1991), this year (1991-1992), and how many do you expect to employ next year (1992-1993)?

| | FTE count | | |
|---|---|---|---|
| | **1990-1991** | **1991-1992** | **1992-1993** |
| Faculty | ________ | ________ | ________ |
| Administrators | ________ | ________ | ________ |
| Support staff | ________ | ________ | ________ |

6. In each of the past three (3) years, how easy or difficult has it been for your program to recruit instructors to teach environmental courses? *(Circle one response for each year.)*

| **Year** | **Very easy** | **Somewhat easy** | **Somewhat difficult** | **Very difficult** |
|---|---|---|---|---|
| 1989-1990 | 1 | 2 | 3 | 4 |
| 1990-1991 | 1 | 2 | 3 | 4 |
| 1991-1992 | 1 | 2 | 3 | 4 |

## II. STUDENT RECRUITMENT AND ENROLLMENTS

7. In this school year (1991-1992), approximately what percentage of all students in hazardous materials courses at your college fall into each of the following categories? *(Please be sure that column sums to 100 percent.)*

| **Percentage** | |
|---|---|
| _____% | Students who have begun their postsecondary education immediately or almost immediately after completing high school |
| _____% | Students who are currently employed or unemployed and are seeking to change careers into the environmental field |
| _____% | Students who are currently employed in jobs requiring knowledge of environmental issues, and their employers are encouraging or requiring them to take environmental courses |
| _____% | Students who are pursuing a personal, rather than a career-related, interest in environmental issues |
| _____% | Other |
| **100%** | TOTAL |

8. Over the past three years (1989-1990 through 1991-1992) how has enrollment in each of your environmental hazardous materials programs changed? *(Based on actual enrollment data, if possible; otherwise, please estimate. Circle one response for each type of program that you offer.)*

| | **Large decrease (>20%)** | **Moderate decrease (6-19%)** | **No or minimal change (±5%)** | **Moderate increase (6-19%)** | **Large increase (>20%)** |
|---|---|---|---|---|---|
| Baccalaureate degree program | 1 | 2 | 3 | 4 | 5 |
| Two-year associate degree program | 1 | 2 | 3 | 4 | 5 |
| Two-year certificate program | 1 | 2 | 3 | 4 | 5 |
| One-year certificate program | 1 | 2 | 3 | 4 | 5 |
| Individual semester (or quarter) length courses that are not part of degree or certificate programs | 1 | 2 | 3 | 4 | 5 |
| On-campus short courses open to the general public | 1 | 2 | 3 | 4 | 5 |
| On-campus or off-campus short courses offered on a contract basis to employees of a single organization | 1 | 2 | 3 | 4 | 5 |
| Other *(specify)* ________________ | 1 | 2 | 3 | 4 | 5 |

9. Over the past three years, have your student enrollment targets for environmental courses *(Check one.)*

☐ Increased
☐ Decreased
☐ Remained the same

10. In each of the past three (3) years, how easy or difficult has it been for your program to meet student enrollment targets for environmental programs? *(Circle one response for each year.)*

| **Year** | **Very easy** | **Somewhat easy** | **Somewhat difficult** | **Very difficult** |
|---|---|---|---|---|
| 1989-1990 | 1 | 2 | 3 | 4 |
| 1990-1991 | 1 | 2 | 3 | 4 |
| 1991-1992 | 1 | 2 | 3 | 4 |

## III. STUDENT OUTCOMES

11. What percentage of students in each of the following environmental programs at your institution complete that program? *(Please estimate if you do not have exact figures; circle one response for each type of program that you offer.)*

| | Less than 20% | 20% to 49% | 50% to 79% | 80% or more |
|---|---|---|---|---|
| Two-year associate degree program | 1 | 2 | 3 | 4 |
| Two-year certificate program | 1 | 2 | 3 | 4 |
| One-year certificate program | 1 | 2 | 3 | 4 |

12. Among students who fail to complete associate degree or certificate programs, what percentage of the failures can be attributed to each of the following factors? *(Please estimate if you do not have exact figures; please be sure that each column sums to 100 percent.)*

| Percentage | | |
|---|---|---|
| **Associate degree** | **Certificate program** | |
| _______% | _______% | Students lack the necessary math and science fundamentals |
| _______% | _______% | Eager employers hire students before they can complete program |
| _______% | _______% | Students are mobile and leave the area |
| _______% | _______% | Students experience financial difficulties paying for school |
| _______% | _______% | Students cannot simultaneously meet work and school demands |
| _______% | _______% | Other *(specify)*_______________________________ |
| **100%** | **100%** | TOTALS |

13. Has your environmental program conducted labor market assessments to identify employer needs for environmental personnel? *(Check one.)*

☐ No —> ***SKIP TO QUESTION #15***

☐ Yes, once, in 19____

☐ Yes, we have conducted more than one assessment, the first in 19____ and most recently in 19____

14. When your program conducted its **initial** and **most recent** labor market needs assessments, did local employers indicate that their need for technician-level environmental personnel would *(Check one in each column; mark only the first column if only one assessment has been conducted.)*

| **Initial assessment** | **Most recent assessment** | |
|---|---|---|
| ☐ | ☐ | Decrease in the near future |
| ☐ | ☐ | Remain about the same in the near future |
| ☐ | ☐ | Increase somewhat in the near future |
| ☐ | ☐ | Increase substantially in the near future |
| ☐ | ☐ | We found that future needs were highly variable, with some employers projecting increases and others projecting declines |

15. How easy or difficult was it **last year** (1990-1991) for students completing each of the following programs to find employment in the environmental field? *(Circle one response for each type of program that you offer.)*

| | **Very easy** | **Somewhat easy** | **Somewhat difficult** | **Very difficult** |
|---|---|---|---|---|
| Baccalaureate degree program | 1 | 2 | 3 | 4 |
| Two-year associate degree program | 1 | 2 | 3 | 4 |
| Two-year certificate program | 1 | 2 | 3 | 4 |
| One-year certificate program | 1 | 2 | 3 | 4 |
| Individual semester (or quarter) length courses that are not part of degree or certificate programs | 1 | 2 | 3 | 4 |
| On-campus short courses open to the general public | 1 | 2 | 3 | 4 |
| On-campus or off-campus short courses offered on a contract basis to employees of a single organization | 1 | 2 | 3 | 4 |
| Other *(specify)* ________________ | 1 | 2 | 3 | 4 |

## IV. STUDENT BACKGROUND AND DEMOGRAPHICS

16. **What are the requirements for admission to your environmental programs?** *(Enter information or check one box for each type of program; leave blank if not applicable.)*

a. For admission to the **baccalaureate degree program** we require

______________________________________________

______________________________________________

☐ See attached description —> ***PLEASE ATTACH INFORMATION TO THIS SURVEY***

b. For admission to the **associate degree program** we require

______________________________________________

______________________________________________

☐ See attached description —> ***PLEASE ATTACH INFORMATION TO THIS SURVEY***
☐ We have no admission requirements

c. For admission to our **certificate program** we require

______________________________________________

______________________________________________

☐ See attached description —> ***PLEASE ATTACH INFORMATION TO THIS SURVEY***
☐ We have no admission requirements

17. **For each type of student below, what is the proportional enrollment for 1991-1992 in environmental associate degree and/or certificate programs?** *(Check box or enter information.)*

☐ We do not offer associate degree or certificate programs —> ***SKIP TO QUESTION #18***

| | **Percentage of total enrollment** | |
|---|---|---|
| **a. Gender** | _____ | Male |
| | _____ | Female |
| | **100%** | |
| **b. Race-Ethnicity** | _____ | White, non-Hispanic |
| | _____ | African American, non-Hispanic |
| | _____ | Hispanic (any race) |
| | _____ | Asian/Pacific Islander |
| | _____ | American Indian/Alaskan Native |
| | _____ | Other |
| | **100%** | |
| **c. Age** | _____ | Under 25 years old |
| | _____ | 25 years old and over |
| | **100%** | |
| **d. Disabled** | _____ | Disabled |
| | **100%** | |

## V. LOCAL EMPLOYERS OF ENVIRONMENTAL PERSONNEL

18. From the list shown below, please indicate the three (3) industries in your local area that provide the largest number of jobs for **all** environmental personnel and specifically for **technician-level** employees: *(Use "1" to indicate the largest employer, "2" for the second largest employer, and "3" for the third largest employer; mark three responses in each column.)*

| **All environmental personnel** | **Technician-level environmental personnel** | |
|---|---|---|
| ____ | ____ | Manufacturing, durable |
| ____ | ____ | Manufacturing, nondurable |
| ____ | ____ | Mining |
| ____ | ____ | Construction |
| ____ | ____ | Transportation and public utilities |
| ____ | ____ | Wholesale/retail trade |
| ____ | ____ | Finance, insurance, real estate |
| ____ | ____ | Health services/health care providers |
| ____ | ____ | Environmental consulting services |
| ____ | ____ | Other services |
| ____ | ____ | Government |
| ____ | ____ | Agriculture |

19. For each of the industries that you ranked in question #18 as providing the largest number of jobs for **all environmental personnel**, what change do you believe will occur in the employment demand for **all environmental personnel** in the next one to three years? *(Circle one response in each row.)*

| | **Demand for all environmental personnel will . . .** | | |
|---|---|---|---|
| | **Decline** | **Remain stable** | **Increase** |
| Industry ranked #1 | 1 | 2 | 3 |
| Industry ranked #2 | 1 | 2 | 3 |
| Industry ranked #3 | 1 | 2 | 3 |

20. For each of the industries that you ranked in question #18 as providing the largest number of jobs for **technician-level personnel**, what change do you believe will occur in the employment demand for **technician-level personnel** in the next one to three years? *(Circle one response in each row.)*

| | **Demand for technician-level personnel will . . .** | | |
|---|---|---|---|
| | **Decline** | **Remain stable** | **Increase** |
| Industry ranked #1 | 1 | 2 | 3 |
| Industry ranked #2 | 1 | 2 | 3 |
| Industry ranked #3 | 1 | 2 | 3 |

## VI. CURRICULUM OBJECTIVES

The following is a list of skills, knowledge, and abilities (SKAs) that may be important for employees working as Environmental Hazardous Materials Technicians or in related jobs. For each SKA listed, please indicate its importance as an objective of your college's environmental associate degree and certificate programs. Please indicate also which courses in your curriculum focus on developing each skill, knowledge, or ability. *(Circle two responses in each row; write in course names as appropriate.)*

| | **How important is this skill, knowledge, or ability?** | | | | | |
|---|---|---|---|---|---|---|
| | **For associate degree students** | | | **For certificate students** | | |
| | **Not at all** | **Somewhat** | **Very** | **Not at all** | **Somewhat** | **Very** |
| **Basic Technical Skills, Knowledge, and Abilities:** | | | | | | |
| 21. High school-level chemistry<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 22. Basic college chemistry<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 23. Introductory-level geology<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 24. High school-level math (algebra, geometry, basic statistics, metrics)<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 25. College math through calculus<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 26. First aid<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| **Basic Nontechnical Skills, Knowledge, and Abilities:** | | | | | | |
| 27. Written communications<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 28. Verbal communications<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 29. Record keeping<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |

| | | How important is this skill, knowledge, or ability? | | | | | |
|---|---|---|---|---|---|---|---|
| | | For associate degree students | | | For certificate students | | |
| | | Not at all | Some-what | Very | Not at all | Some-what | Very |
| 30. | Problem solving<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 31. | Comprehension of technical written material & instructions<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 32. | Teamwork<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 33. | Time management<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| **Knowledge of and ability to follow standard operating procedures for . . .** | | | | | | | |
| 34. | Responding to chemical spills<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 35. | Labeling hazardous wastes<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 36. | Site evacuation<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 37. | Maintaining protection<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 38. | Handling hazardous waste<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 39. | Responding to radioactive releases<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 40. | Following EPA regulations<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |

|  |  | How important is this skill, knowledge, or ability? |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
|  |  | For associate degree students |  |  | For certificate students |  |  |
|  |  | Not at all | Somewhat | Very | Not at all | Somewhat | Very |
| 41. | Following OSHA regulations<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 42. | Maintaining chain of custody<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 43. | Handling hazardous waste drums<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| **Knowledge of and ability to . . .** |  |  |  |  |  |  |  |
| 44. | Participate in a site evacuation<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 45. | Monitor hazardous waste storage areas<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 46. | Sample hazardous materials<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 47. | Read gauges<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 48. | Operate monitoring equipment<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 49. | Operate radiation detection equipment<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 50. | Pack hazardous waste<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 51. | Maintain a closed system<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |

**How important is this skill, knowledge, or ability?**

| | | For associate degree students | | | For certificate students | | |
|---|---|---|---|---|---|---|---|
| | | **Not at all** | **Somewhat** | **Very** | **Not at all** | **Somewhat** | **Very** |
| 52. | Sample water and/or sludge<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 53. | Pump hazardous materials<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 54. | Apply the principles of toxicology<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| **Other Important Skills, Knowledge, or Abilities** | | | | | | | |
| 55. | ____________________<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 56. | ____________________<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 57. | ____________________<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 58. | ____________________<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |
| 59. | ____________________<br>Courses: ____________________<br>____________________ | 1 | 2 | 3 | 1 | 2 | 3 |

## VII. RESPONDENT INFORMATION

60. In case we need to contact you, could you please provide the following information.

NAME: ______________________________

JOB TITLE: ______________________________

WORK ADDRESS:

______________________________

______________________________

______________________________

TELEPHONE: ______________________________

ADDITIONAL COMMENTS:

***THANK YOU FOR PARTICIPATING IN THIS SURVEY.***